



VER 1.3 **Technical Manual**

DS-CLS3-FETC-4I



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1. Introduction

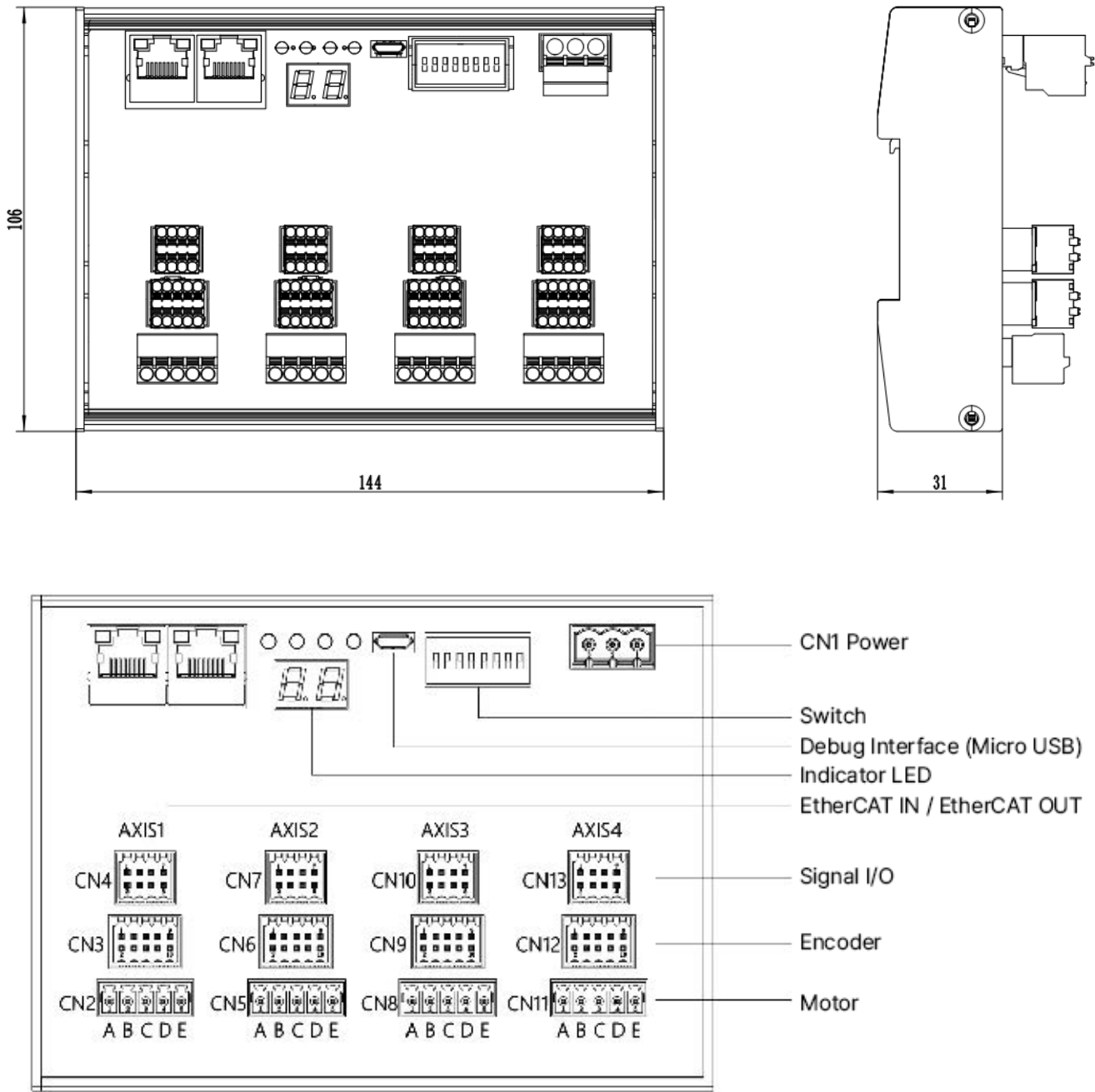
1.1 Features

- Input power supply : DC 24V~36V
- Output current of each axis motor (peak) : 0.4~3.0A
- Maximum support for 4-axes control
- Compatible with 2-phase open/closed-loop, 3-phase open-loop, 5-phase open-loop stepper motors.
- EtherCAT communication control, supporting control modes PP, PV, HM, CSP
- Optoelectronic isolation input function
- Motor short-circuit protection, undervoltage protection, overvoltage protection, overcurrent protection and other functions

1.2 Specifications

Model		DS-CLS3-FETC-4I
Adapted motor		Compatible with 2-phase open/closed-loop incremental, 3-phase open-loop, and 5-phase open-loop stepper motors, with peak current support up to 3.0A.
Power supply		DC 24V ~ 36V
Output current		0.4A ~ 3.0A/phase (peak)
Drive method		Full-bridge bipolar PWM drive
Device initialization time		2s
Input signal	1 probe input	Optocoupler input voltage : H = 24V , L = 0 - 0.8V On current 5~8mA
	3 universal input signal	
Output signal	2 universal output signal	Optoelectronic isolation output, maximum withstand voltage 30VDC, maximum saturation current 50mA
Dimensions		144×106×31 mm (Excluding connectors)
Weight		about 450g
Apply environment	Application	Avoid dust, oil mist and corrosive gases
	Humidity	< 85 % RH, Non-condensing
	Operating temperature	0°C ~ +40°C
	Storage temperature	-10°C ~ +75°C
	Heat dissipation	Installation in a ventilated environment

1.3 Dimensions (mm)



■ Drive Installation

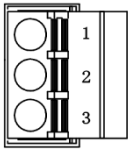
Install the driver using the narrow side, and secure it through the mounting holes on both sides with M4 screws. As the power components inside the driver generate heat, sufficient heat dissipation or forced cooling is required when operating continuously under high input voltage and high power conditions.

Do not use the driver in poorly ventilated areas or environments where the ambient temperature exceeds 40°C.

Avoid installing the driver in humid locations or areas where metal particles may be present.

2. Description of Interface

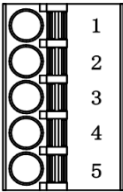
2.1 CN1 (Power supply)

Terminal number	Icon	Pin.	Signal name
CN1		1	POWER V+ DC24V ~ 36V
		2	POWER GND
		3	Frame Ground FG

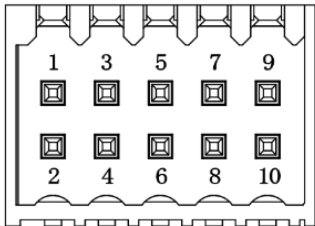
Pay attention to the polarity of the power supply when wiring

Wire specifications: AWG20~AWG16 (multi stranded wire)

2.2 CN2/CN5/CN8/CN11 (Axis 1/Axis 2/Axis 3/Axis 4 motor wiring)

Terminal number	Icon	Pin.	Signal name		
CN2		1	Motor A+	Motor U	Motor A
CN5		2	Motor A	Motor V	Motor B
CN8		3	Motor B+	Motor W	Motor C
CN11		4	Motor B-	NC	Motor D
		5	NC	NC	Motor E

2.3 CN3/CN6/CN9/CN12 (Axis 1/Axis 2/Axis 3/Axis 4 encoder input)

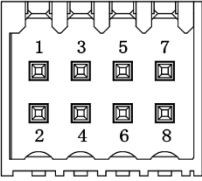
Terminal number	Illustration	Pin.	Signal name
CN3 CN6 CN9 CN12		1	FG
		2	FG
		3	+5V
		4	0V
		5	EZ+
		6	EZ-
		7	EB+
		8	EB-
		9	EA+
		10	EA-



Notes

The driver outputs a 5V signal for the encoder, with a maximum current of 100mA

2.4 CN4/CN7/CN10/CN13 (Definition of input/output ports for axis 1/axis 2/axis 3/axis 4)


Terminal number	Illustration	Pin.	signal name	Description
CN4 CN7 CN10 CN13		1	COM_IN	Single ended input signal common end, compatible with both positive and negative (24VDC)
		2	TP1	High speed input port, maximum input frequency 100KHz
		3	COM_OUT	Output common cathode terminal (0V)
		4	IN1	Universal input port, effective from 18 to 24V, maximum input frequency of 1KHz, signal definition configurable
		5	OUT1	Single ended output signal, common negative connection method, maximum output current 50mA, maximum withstand voltage 30VDC. Output function configurable
		6	IN2	Universal input port, effective from 18 to 24V, maximum input frequency of 1KHz, signal definition configurable
		7	BK	Band brake output, common negative connection method, maximum output current 50mA, maximum withstand voltage 30VDC.
		8	IN3	Universal input port, effective from 18 to 24V, maximum input frequency of 1KHz, signal definition configurable

2.5 CN14 MicroUSB B Debug Interface

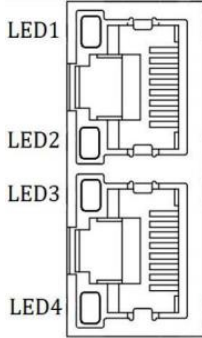


Notes

USB change MicroUSB B Debugging line not exceeding 2 meters

Terminal No.	Illustration	Name	Description
CN14		MicroUSB B Debug Port	Debug cable should not exceed 2 meters

2.6 CN15 (OUT) / CN16 (IN) (EtherCAT BUS)

Terminal number	Illustration	Pin.	signal name	Description
CN15 CN16		1,9	E_TX+	EtherCAT Data sending positive
		2,10	E_TX-	EtherCAT Data sending negative
		3,11	E_RX+	EtherCAT Data receiving positive
		4,12	-	-
		5,13	-	-
		6,14	E_RX-	EtherCAT Data receiving negative
		7,15	-	-
		8,16	-	-
		SHELL	PE	SHGROUND



Notes

Definition explanation of RJ45 Ethernet port light

LED	Name	Color	State	Description
LED1	Link/Activity IN	Green	Off	Physical layer link not established
			On	Physical layer link establishment
			Blink	Interactive data after link establishment
LED2	RUN	Green	Off	Initialization status
			Blink	Pre operation status
			Single	Safe working condition
			On	Operational state
LED3	Link/Activity OUT	Green	Off	Physical layer link not established
			On	Physical layer link establishment
			Blink	Interactive data after link establishment
LED4	ERR	Red	Off	No errors
			Slow Blink	Communication settings error
			Single	Synchronization error or communication data error
			Double	Request for watchdog timeout
			Fast Blink	Boot error
			On	Internal bus watchdog timeout

2.7 Address Allocation

SW1	SW1	SW1	SW1	SW1	SW1	SW1	SW1	Hex Address	Decimal Address
OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	01H	1
OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	02H	2
OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	03H	3
OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	04H	4
OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	05H	5
Station Number									
ON	ON	ON	ON	ON	OFF	OFF	ON	FAH	250
ON	ON	ON	ON	ON	OFF	ON	OFF	FBH	251
ON	ON	ON	ON	ON	OFF	ON	ON	FCH	252
ON	ON	ON	ON	ON	ON	OFF	OFF	FDH	253
ON	ON	ON	ON	ON	ON	OFF	ON	FEH	254
ON	ON	ON	ON	ON	ON	ON	OFF	FFH	255
ON	ON	ON	ON	ON	ON	ON	ON	N/A*	N/A*

2.8 Indicator Light

2.8.1 Status Indication

Method: The module completes the following flashing pattern to indicate status (0.5s OFF, 0.5s ON), repeats the cycle 2 times, then pauses for 2 seconds before repeating.

State	Code	Description
System Powered Off	1	Power disconnected, driver disabled, motor in free state
System Powered On	2	Power on, no input signal, driver enabled, motor not running
Motor Running	3	Input signal present, motor running

2.8.2 Error Indication

Method: The module completes the following flashing pattern to indicate fault (0.5s OFF, 0.5s ON), repeats the cycle 2 times, then pauses for 2 seconds before repeating.

Alarm	Code	Description
Overcurrent	10	Motor current exceeds protection threshold
Undervoltage	11	Power supply voltage below 10V
Overvoltage	12	Power supply voltage exceeds 45V
Overtemperature	13	Motor temperature too high
Other Faults	14 or others	Other unspecified fault conditions

3. Power Supply

3.1 Voltage

The chopping wave driver continuously changes the magnitude and direction of the motor winding terminal voltage while detecting the current to obtain accurate phase current. If both high efficiency and low noise are to be ensured, the power supply voltage of the driver should be at least 5 times the rated phase voltage of the motor (i.e. the rated phase current of the motor \times Phase resistance)

If you need the motor to achieve better high-speed performance, you need to increase the power supply voltage of the driver.

If using a regulated power supply, it is required that the supply voltage should not exceed 36V.

If using a non regulated power supply, the voltage must not exceed 25V.

Because the rated current of a non regulated power supply is full load current; When the load is light, such as when the motor is not rotating, the actual voltage can reach 1.4 times the rated voltage of the power supply. To ensure smooth and quiet operation of the motor, choose low voltage.

3.2 Current

The maximum power supply current should be the sum of the two-phase currents. Usually, the current


you need depends on the motor model, voltage, speed, and load conditions. The actual power supply current value is significantly lower than this maximum current value because the driver uses a switching amplifier, which converts high voltage and low current into low voltage and high current. The more the power supply voltage exceeds the motor voltage, the less power supply current is required.

3.3 Regeneration of discharge

When the motor decelerates, it will convert the kinetic energy of the load into electrical energy like a generator. Some energy will be consumed by the driver and motor. If your application has a large load running at high speed, a considerable amount of kinetic energy will be converted into electrical energy.

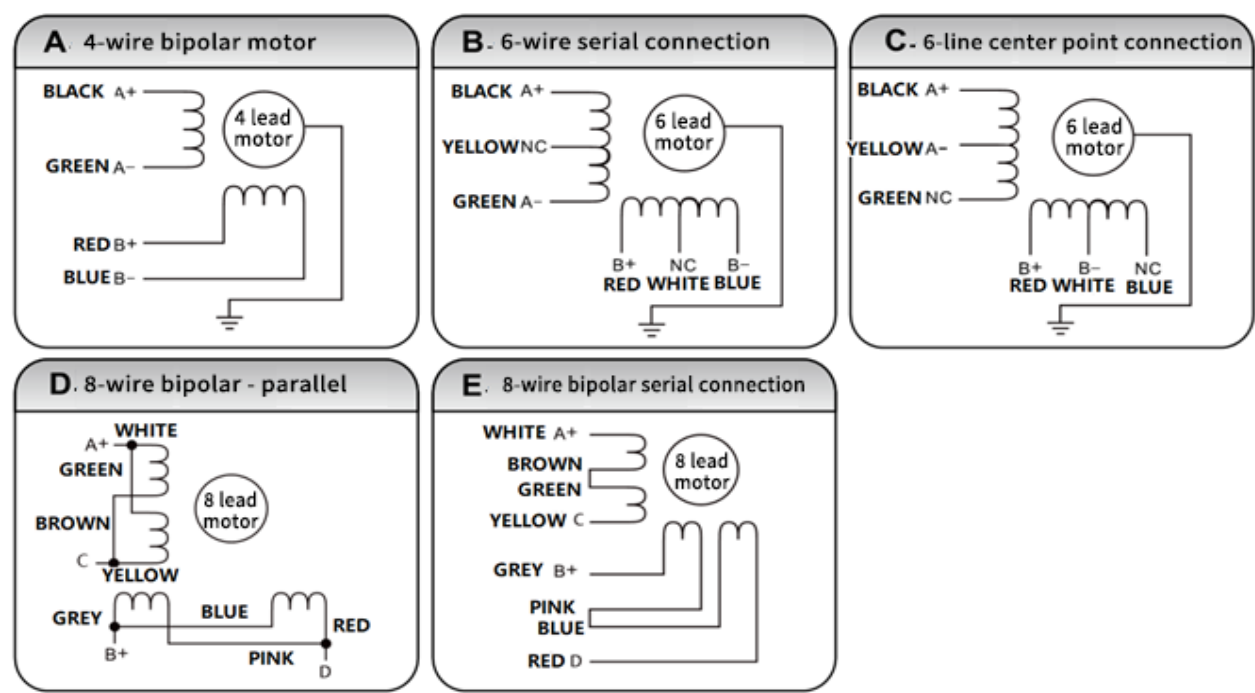
Usually, simple linear power supplies have a large capacitor to absorb this energy without causing damage to the system. Switching power supplies often turn off under overvoltage conditions, and excess energy can be transmitted back to the drive, which may cause damage to the drive. Therefore, in this case, an external absorption resistor or capacitor should be connected.

4. Motor Connection

**Warning**

When connecting the motor to the drive, please first confirm that the power to the drive is turned off. Confirm that the unused motor leads are not short circuited to other objects. During the power on period of the drive, the motor cannot be disconnected. Do not connect the motor leads to the ground or power supply.

4.1 Two phase motor wiring



- 1) Four wire motors can only be connected in one way.
- 2) Six wire motors can be connected in two ways: full group and half group. In full group mode, the

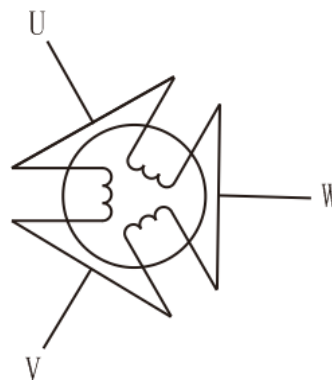
motor has greater torque when operating at low speeds, but cannot run as quickly as when connected to a half group. When the entire group is running, the motor needs to operate at a current of less than 30% of the half group mode to avoid overheating.

- 3) Eight wire motors can be connected in two ways: series and parallel. The series connection method has a higher torque at low speeds and a lower torque at high speeds. When operating in series, the motor needs to operate in parallel with 50% of the current to avoid overheating

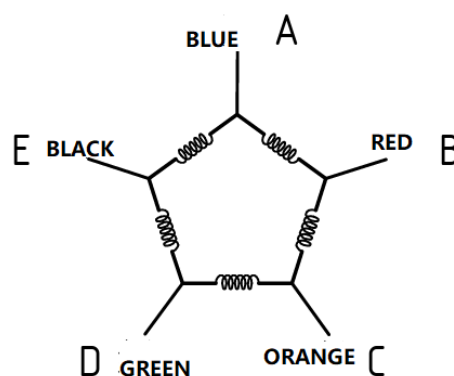
Attention:

- 1) Different motor leads correspond to different colors, please refer to the motor information when using them.
- 2) The windings of different phases of the motor cannot be connected to the terminals of the same phase of the driver (A+, A - is one phase, B+, B - is another phase). If the motor's direction of rotation is different from the expected direction, only exchange the positions of A+ and A -.
- 3) This driver can only drive two-phase hybrid stepper motors and cannot drive three-phase and five phase stepper motors.

4.2 Three phase motor wiring



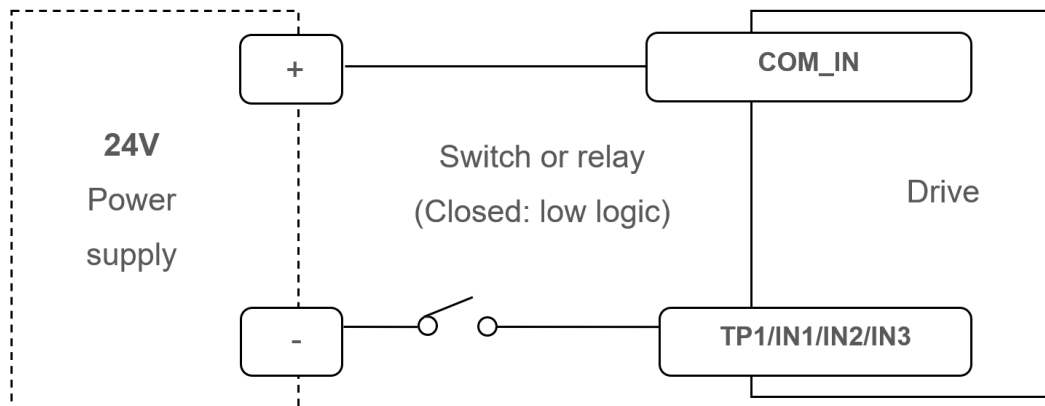
4.3 Five phase motor wiring



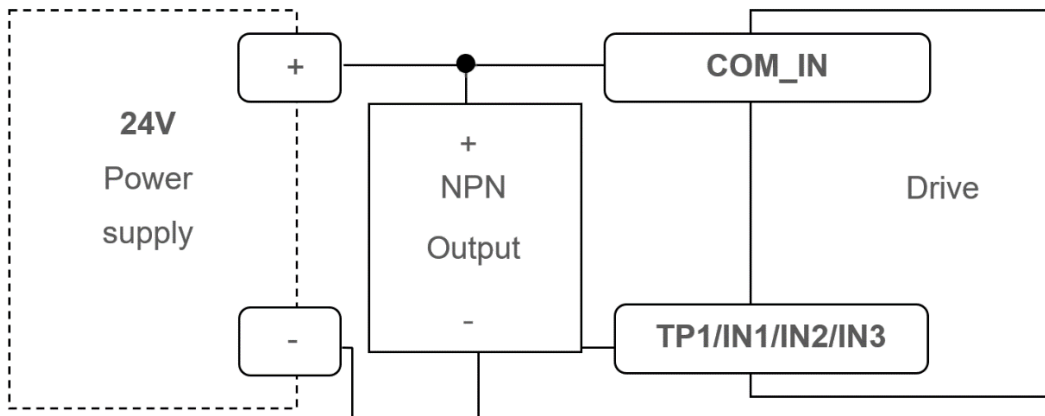
The colors corresponding to different motor leads are different. Please refer to the motor information when using them.

5. Input / Outputs Connection

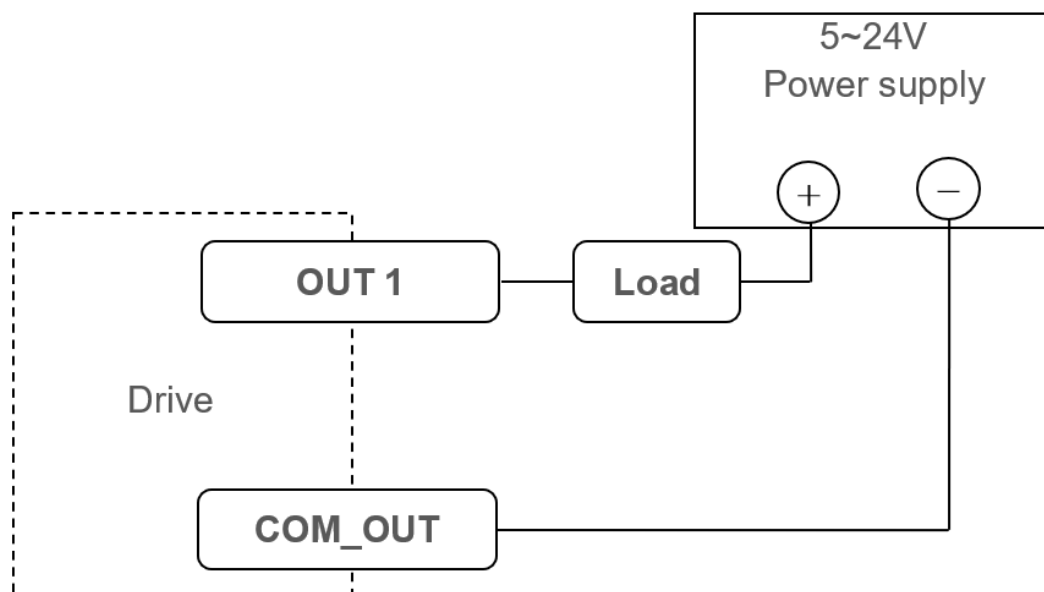
5.1 Input wiring with switch or relay



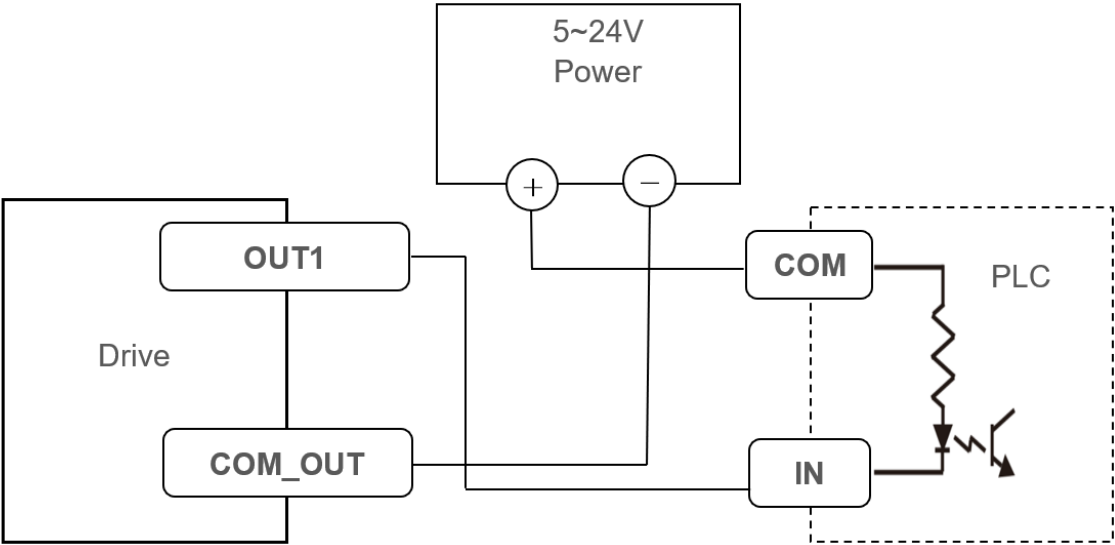
5.2 Input wiring with NPN type output



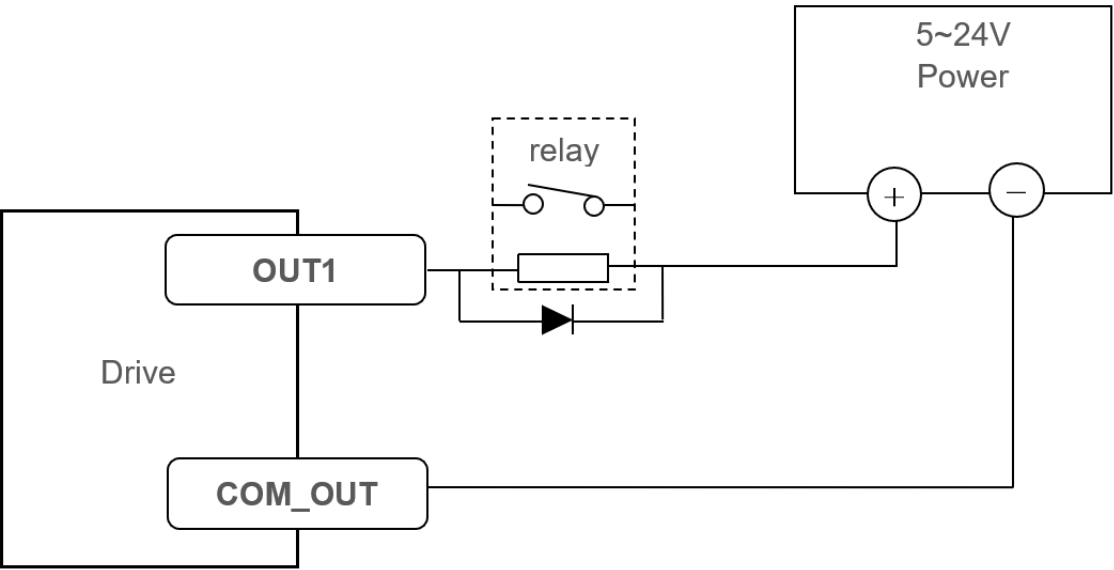
5.3 Default output interface




5.4 Outputs interface to optocouplers



5.5 Outputs interface to relay





Warning

Do not connect the output terminal to a DC voltage above 30V, and do not exceed 50mA of current flowing into the output terminal

6. Wiring Requirements

- 1) To prevent interference to the driver, it is strongly recommended to use shielded cables for control signals. The shielding layer should be connected to ground.
Unless otherwise specified, the shield should be grounded at only one end—typically at the controller (host) side, while the driver side remains floating.
Only single-point grounding is permitted within the same machine.
If the ground point is not a true earth ground, it may introduce significant interference. In such cases, the shield should remain unconnected.
- 2) Pulse and direction signal cables must not be bundled together with motor cables.
To avoid electromagnetic interference from the motor, these cables should be separated by at least 10 cm. Failure to do so may lead to positioning errors, unstable operation, and other signal-related faults.
- 3) When multiple drivers share a single power supply, connect them in parallel at the power source.
Daisy-chaining power lines from one driver to another is strictly prohibited.
- 4) Do not plug or unplug motor and power terminals while the system is powered.
Even when the motor is stopped, significant current may still flow through the coils.
Plugging or unplugging under power can cause a large induced voltage spike, which may severely damage the driver.
- 5) Do not solder the ends of wires before inserting them into terminals.
Doing so can increase contact resistance, leading to overheating and terminal failure.
- 6) Ensure that no part of the wire is exposed outside the terminal block.
Exposed wire increases the risk of accidental short circuits and may result in driver damage.

7. Parameter Description

7.1 SDO Parameters

The bus type closed-loop stepper driver is a standard EtherCAT slave device that follows the EtherCAT standard protocol and can communicate with standard master stations that support this protocol.

The PC software interacts with the driver using the MODBUS protocol. The PC software can modify / read all parameters, alarm information, and control the driver for trial operation.

7.1.1 Configuration parameters

The configuration parameter address consists of a base address and an axis number.

The starting numbers of each axis for configuration parameters are calculated using the following formula.

Configuration parameter address = $0x2000 + (\text{axis number} - 1) \times 0x200$

Axis number	Address
Axis 1	2000~21FF
Axis 2	2200~23FF
Axis 3	2400~25FF
Axis 4	2600~27FF

Taking axis 1 as an example :

Object Dictionary	Name	R/W	Word	Range	Default	Unit	Note
2064	Rated current display	RO	1	0~65535	--		
2065	Bus voltage	RO	1	0~65535	--		
206C	Error code	RO	1	0~65535	--		
206D	Running state	RO	1	0~65535	--		
206E	Hardware version	RO	1	0~65535	--		
206F	Software version	RO	1	0~65535	--		
20C9	Running direction	RW	1	0~3	0		Bit0=0: not change the running direction bit0=1: changes the running direction.
20CE	Control command	RW	1	0~5	0		
20D5	Idle current	RW	1	10~120	50		The stopping current is the percentage of operating current.
20D9	Motor mode setting	RW	1	0~2	0		0 : open loop 1 : closed loop
20E0	Filter coefficient	RW	1	0~500	50		The smaller the value, the smoother the motor runs, but the higher the delay.
20F1	Current setting	RW	1	0~3000	1000	0.1%A	

20F2	Resolution settings	RW	2	200~102400	10000	ppr	
20F5	Idle current time	RW	1	1~30000	200	ms	The delay time (ms) for the motor to enter the half current state after stopping operation.
20F6	Encoder resolution	RW	1	200~65535	4000		Resolution=number of encoder lines x4.
20F7	In place range	RW	1	1~1000	5		
2102	Position deviation threshold	RW	1	1~30000	1000		Position deviation threshold, the value is the encoder resolution.
213D	Positive limit position	RW	2	-2,000,000,000~2,000,000,000	2,000,000,000	pulse	
213F	Negative limit	RW	2	-2,000,000,000~2,000,000,000	-2,000,000,000	pulse	
2144	Memory control switch	RW	1	0~65535	0		Bit0: Enable the forward soft limit function. Bit1: Enable reverse soft limit function.
2190	IN1	RW	1	0~23	0		
2191	IN2	RW	1	0~23	0		
2192	IN3	RW	1	0~23	0		
21A4	OUT1	RW	1	100~109	101		
21A5	OUT2	RW	1	100~109	101		
21AD	Input port logic	RW	1	0~65535	RW		
21AE	Output port logic	RW	1	0~256	RW		

10.1.2 Motion parameters

The motion parameter address consists of a base address and an axis number.

The starting numbers of each axis of the motion parameters are calculated using the following formula.

Motion parameter address=0x6000+(axis number -1) × 0x800

Axis number	Address
Axis 1	6000~67FF
Axis 2	6800~6FFF
Axis 3	7000~77FF
Axis 4	7800~7FFF

Taking axis 1 as an example :

Object Dictionary	Name	R/W	Word	Range	Default	Unit	Note
603F	Error register	R	1	0~65535	0	--	
6040	Control word	R/W	1	0~65535	0	--	
6041	Status word	R	1	0~65535	0	--	
6060	Mode	R/W	1	0-255	1	--	1 – PP 3 - PV 4 – TQ 6 - HOME 8 – CSP 9 - CSV

6061	Operation mode display	R	1	0-255	0	--	
6064	Actual position	R	2	-2147483647~ 2147483647	0	pulse	
606C	Actual Speed	R	2	-2147483647~ 2147483647	0	0.01rps	
607A	Target Position	R/W	2	-2147483647~ 2147483647	0	pulse	PP mode 1 Target position command
607C	Zero offset	R/W	2	-2147483647~ 2147483647	0	pulse	
6081	Trapezoidal velocity	R/W	2	1~5000	100	0.01rps	PP mode 1 maximum speed
6083	Acceleration	R/W	2	1~5000	50	rps^2	pp, pv mode 1,3 acceleration
6084	Deceleration	R/W	2	1~5000	50	rps^2	pp, pv mode 1,3 deceleration
6098	Zero method	R/W	1	0~ 100	21	--	
6099+1	Zero approach velocity	R/W	2	1~5000	200	0.01rps	
6099+2	Zero peristaltic velocity	R/W	2	1~5000	100	0.01rps	
609A	Zero return acceleration and deceleration	R/W	2	5~10000	50	rps^2	
60B8	Probe control word	R/W	1	0~65535	0	--	Set probe function
60B9	Probe status word	R	1	0~65535	0	--	Probe action status
60BA	Probe data 1	R	2	-2147483647~ 2147483647	0	P	Probe1 rising edge capture data
60BB	Probe data 2	R	2	-2147483647~ 2147483647	0	P	Probe1 falling edge capture data
60FD	Input Port Status	R	2	0~ 4294967296	0	--	bit0 : Negative limit bit1 : Positive limit bit2 : zero bit16~18 : IN1~IN3 state
60FE+1	Universal output	R/W	2	0~ 4294967296	0	--	
60FE+2	Match bits	R/W	2	0~ 4294967296	0	--	
60FF	Target speed	R/W	0	-5000~5000	0	-	CSV mode target speed

8.Common Functions

8.1 Control and operation mode

In synchronous motion mode, the master handles trajectory planning and sends cyclic commands. The driver receives these commands based on a defined synchronization cycle, enabling precise multi-axis coordinated motion. This product supports Cyclic Synchronous Position (CSP) mode.

Under CSP mode, the trajectory is fully planned by the master. The driver receives position data from the master in real time according to the synchronization cycle and immediately executes the motion upon receiving the synchronization signal. Supported synchronization cycles include 1000 μs, 2000 μs, and 4000 μs.

The master is responsible only for delivering motion parameters and control commands. Once a motion start command is received, the closed-loop stepper driver performs the motion trajectory based on the parameters provided by the master.

In asynchronous motion mode, each motor axis operates independently. Supported asynchronous modes include:

- Profile Position Mode (PP)
- Profile Velocity Mode (PV)
- Homing Mode (HM)

Regardless of the control mode, data exchange between the EtherCAT master and slave is handled through an Object Dictionary. Two communication types are available: PDO (Process Data Object) and SDO (Service Data Object). Typically, only one method is used depending on system requirements. Based on the control needs and real-time performance requirements, object dictionary mappings are categorized into three priority levels:

- Mandatory: The object must be configured for PDO mapping.
- Recommended: PDO mapping is advised to ensure real-time performance and better control. However, SDO may be used if real-time demands are low.
- Optional: The object is generally handled via SDO and does not require PDO mapping.

A detailed table of the object dictionaries associated with each control mode is provided below.

Dictionary of objects associated with each control mode							
Control model	Index + sub index	Name	Type	Access type	Unit	PDO set	SDO com
CSP mode (8)	6040-00h	Control word	U16	RW	-	must	-
	607A-00h	Target position	I32	RW	pulse	must	-
	6041-00h	Status word	U16	RO	-	must	-
	6064-00h	Actual position	I32	RO	pulse	must	-
	606C-00h	Actual speed	I32	RO	0.01rps	can	can

PP mode (1)	607A-00h	Target position	I32	RW	pulse	suggest	can
	6081-00h	Maximum speed	U32	RW	0.01rps	can	can
PV mode (3)	6040-00h	Control word	U16	RW	-	suggest	can
PP mode (1)	6083-00h	Acceleration	I32	RW	rps ^2	can	can
PV mode (3)	6084-00h	Deceleration	U32	RW	rps ^2	can	can
HOME mode (6)	6040-00h	Control word	U16	RW	-	suggest	can
	6098-00h	Zero return method	I8	RW	-	can	can
	6099-01h	Zero Fast	U32	RW	0.01rps	can	can
	6099-02h	Zero slow	U32	RW	0.01rps	can	can
	609A-00h	Zero acceleration	U32	RW	rps ^2	can	can
	607C-00h	Zero Offset	U32	RW	pulse	can	can
PP, PV and HOME mode	6041-00h	Status word	U16	RO	-	suggest	can
	6064-00h	Actual position	I32	RO	pulse	suggest	can
	606C-00h	Actual speed	I32	RO	0.01rps	can	can
TQ Mode	6040-00h	Control Word	U16	RW		mandatory	can
	6041-00h	Status Word	U16	RO		mandatory	can
	6071-00h	Target Torque	I16	RW		mandatory	can
	6074-00h	Torque Demand				suggest	can
	6077-00h	Actual Torque				suggest	can
	6087-00h	Torque Slope				mandatory	can
Common to All Modes	60B8-00h	Probe Function	U16	RW	-	suggest	can
	60B9-00h	Probe Status	U16	RO	-	suggest	can
	60BA-00h	Probe 1 Capture Value	I32	RO	P	can	can
	60FD-00h	Digital Input	U32	RO	-	suggest	can
	603F-00h	Last Error Code	U16	RO	P	suggest	can
Other associated parameters	6060-00h	MODE	I8	RW	-	can	can
	60B0-00h	Position offset	I32	RW	-	can	can
	6082-00h	Jumping Speed	U32	RW	0.01rps	can	can
	6085-00h	Emergency stop deceleration	U32	RW	rps ^2	can	can
	6061-00h	Operation mode display	I8	RO	-	can	can

No matter which control mode is used to achieve driving control of the actuator, it cannot be separated from the reading and writing of the control word 6040h and the status word and 6041h object dictionaries. The master and slave stations use these two object dictionaries as media to issue instructions and monitor the status. The following focuses on the definitions of each bit in these two object dictionaries.

The definition of control word (6040h) is shown in the table below. The left half of the table describes bits 4 to 6 and bit 8, which depend on the operating mode and mainly control the execution or stopping of each mode; The right half of the table describes bit0~3 and bit7, which together manage the state transition changes of the 402 state machine to meet complex and diverse control requirements. The definition of status word (6041h) is shown in the definition table of status word (6041h) bits. Bit0~bit7

mainly displays the transition status of the 402 state machine, while bit8~bit15 mainly displays the motion execution or stop status in various control modes. The typical state transitions that enable are as follows:

Initial (00h) - Power on (06h) - Start (07h) - Enable (0fh) - Execute run or pause (depending on the operating mode, combined with bit4-6 and bit8)

Issue relevant control instructions. The state transitions that trigger operation control in each control mode are shown in the state transition table for each mode control operation.

Definition of control word (6040h) bits												
Mode/bit	15~9	8	6	5	4	7	3	2	1	0	Typical	Result
Share	-	Pause	Depending on the operating mode			Error reset	Allow operation	Quick stop	Voltage output	Start		
CSP mode 8	-	Invalid	Invalid	Invalid	Invalid	0	0(x)	1	1	0	06h	Gain power
PP mode 1	-	Deceleration stop	Absolute/relative	Immediately trigger	New Location Point	0	0	1	1	1	07h	Start
PV mode 3	-	Deceleration stop	Invalid	Invalid	Invalid	0	0(x)	0	1	0(x)	02h	Quick stop
HM mode 6	-	Deceleration stop	Invalid	Invalid	Start movement	0	1	1	1	1	0fh	Enable
TQ Mode 4		Deceleration stop	Invalid	Invalid	Invalid	0	0(x)	0	1	0(x)	02h	Quick stop
None						1	0(x)	0(x)	0(x)	0(x)	80h	Clear
None						0	0	0	0	0	0	Initial

Additional explanation for other positions:

Bit 2 quick stop trigger logic is 0 effective, please distinguish it from other triggered logic.

Bit 7 error reset trigger logic is effective on the rising edge.

Bit 5 immediately triggers the triggering logic, and the rising edge is valid.

Status word (6041h) bit definition								
Mode/low8	7	6	5	4	3	2	1	0
Share	Reserve	Not started	Quick stop	Gain power	Error	Allow operation	Start	Pre-start
Mode/high8	15	14	13	12	10	8	11	9
Share	Depending on the operation mode						Limit effective	Remote
CSP mode8	Invalid	Invalid	Invalid	Follow effectively	Invalid	Abnormal stop	Set when hardware limit is valid	0 below PreOP
PP mode1	Triggering response	Parameter has 0	Invalid	New location point response	Position reach	Abnormal stop		
PV mode 3	invalid	Parameter has 0	Invalid	Speed is 0	Speed reached	Quick stop		
HM mode 6	Triggering response	Parameter has 0	Zero error	Origin completed	Position reach	Abnormal stop		
TQ mode 4	invalid	Parameter has 0	invalid	invalid	Position reach	Quick stop		

Additional explanation for other positions:

When the drive is powered on, bit 4 will be set.

Bit 5 quickly stops activation and is only effective under logic 0, which is opposite to the logic of other bits.

Bit 9 is remote, displaying the communication status machine status, which is 0 below ProOP. At this time, the command of the control word (6040h) will not be executed.

Bit 11 limit is set only when the hardware limit is valid.

Bit 8 stops abnormally and is generally effective when triggered by hardware limit, deceleration stop, and fast stop.

Bit 12 follows the master station. In CSP, if the driver is not enabled or no longer follows the master station's instructions, this position is 0.

State transitions of each mode control operation										
	Method	0	1	2	3	4	5	6	7	8
Mode	Action	Preparatory work	Initial	Gain power	Initial	Enable	Start work	Displacement	Cease	Fault
CSP mode8	6040	Establish communication OP status and activate NC axis	00h	06h	07h	0fh	1fh main station sends instructions	Master station control	Master station stop position command	-
	6041		250h	231h	233h	1237h	1237h	1237h	1237h	238h
PP mode1	6040	Establish communication OP status and set motion parameters	00h	06h	07h	0fh	-	2 fh→3fh	10fh	-
	6041		250h	231h	233h	8237h	1237h	1637h→1237h	1737h	1238h
PV mode3	6040	Establish OP status and set motion parameters	00h	06h	07h	0fh	Run immediately after enabling	Change speed is sufficient	10fh	-
	6041		250h	231h	233h	1637h	1637h	1637h	1737h	1638h
HM mode6	6040	Establish OP status and set motion parameters	00h	06h	07h	0fh	1fh	Invalid	10fh	-
	6041		250h	231h	233h	8337h	237h	237h	737h	238h
TQ mode4	6040	Establish OP status and set motion parameters	00h	06h	07h	0fh	Run immediately after enabling	Change speed is sufficient	10fh	-
	6041		250h	231h	233h	1637h	637h	637h	1637h	1638h

Additional explanation for other positions:

When changing the position of PP mode, it is necessary to give the rising edge of bit5 of the control word in order to start a new position movement.

8.2 Probe capture function

The probe function is to use input signals with probe function to capture the actual position of the motor and record it. The driver has two input IO signals that support probe function and can be enabled simultaneously. The dictionary of probe function related objects is shown in the table below.

Dictionary of Object Related to Probe Function						
Object Dictionary	Bitwise or Object Dictionary Meaning					
60B8h	7~6	5	4	3~2	1	0
	-	Probe 1 falling edge triggered	Probe 1 rising edge triggered	-	Probe 1 mode	Probe 1 enable
	15~14	13	12	11~10	9	8
	-	Probe 2 falling edge triggered	Probe 2 rising edge triggered	-	Probe 2 mode	Probe 2 enable
60B9h	7	6	5~3	2	1	0
	Actual level of probe 2	Actual level of probe 1		Probe 1 Lower Rising Edge Trigger Completed	Probe 1 rising edge trigger completed	Probe 1 in action
	15~11			10	9	8
	-			Probe 2 Lower Rising Edge Trigger Completed	Probe 2 rising edge trigger completed	Probe 2 in action
60BAh	Probe 1 rising edge capture data value register					
60BBh	Probe 1 falling edge capture data value register					
60BCh	Probe 2 rising edge capture data value register					
60BDh	Probe 2 falling edge capture data value register					
60FDh	Bit1 and bit2 with bit26 status 60B9 and logic, and bit9 and bit10 with bit27 status 60B9 and logic					
2152h	Its sub-indexes 01h and 02h can be written to 17 or 18 to configure as probe 1 or probe 2 functions					

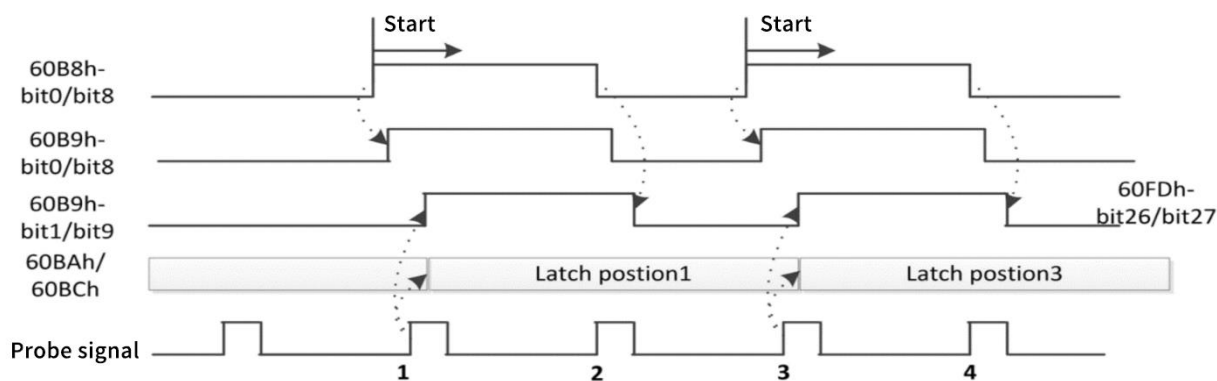
Additional explanation for other positions:

Bit0 and bit8 for 60B8h: respectively, are the enable and stop control positions of probe 1 and probe 2, with the rising edge effective.

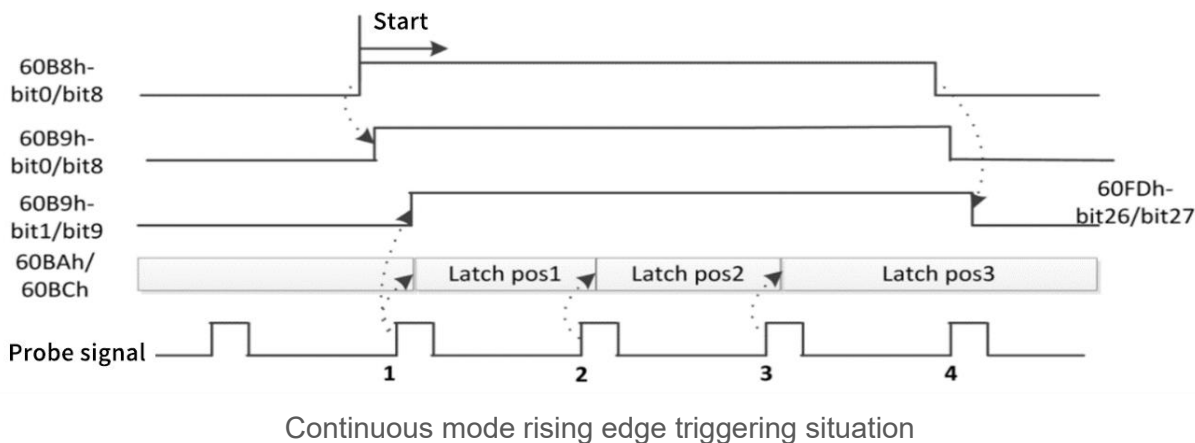
Bit1 and bit9 at 60B8h: The probe mode is divided into single mode and continuous mode

Single mode: After the probe is started, it is only captured under the first trigger signal. In order to capture the new position value again, a rising edge signal must be given to bit0/bit8 of the 60B8 object to restart the probe action.

Continuous mode: After the probe is started, capture action is performed under each triggering signal.



Single mode rising edge triggering situation



8.3 Encoder resolution

The encoder resolution of this drive is 10000, and it is matched with a 2500 line encoder motor by default. If the user is using a 5000 line encoder motor, the encoder resolution needs to be changed to 20000 (4x frequency).

The encoder resolution can be set through the object dictionary of the main station PLC, which is 0x20F6. You can also debug software settings through the upper computer

Set, as shown below :

Object dictionary	Name	R/W	Word	Range	Default	Unit	Note
20F6	Encoder resolution	RW	1	200~4096	4000		Resolution=number of encoder lines x 4

8.4 Output peak current

If the matching motor is for frame 42 and below, before connecting the motor for the first time, it is necessary to modify the peak output current of the driver to prevent excessive output current from burning the motor.

The peak current output can be modified by setting the object dictionary of the main station PLC, which is 0x20F1. It can also be modified by debugging software on the upper computer, as follows

Object dictionary	Name	R/W	Word	Range	Default	Unit	Note
20F1	Current setting	RW	1	0~3000	1000	0.1%A	

8.5 Error codes

Fault Description

603F object	Meaning
0x2211	Overcurrent fault
0x7120	Motor open circuit
0x3220	Undervoltage
0x3210	Overvoltage
0x8611	Position error too large error
0xFF23	Emergency stop
0xFF19	Position following error
0xFF18	Motor overspeed
0xFF32	Communication instability

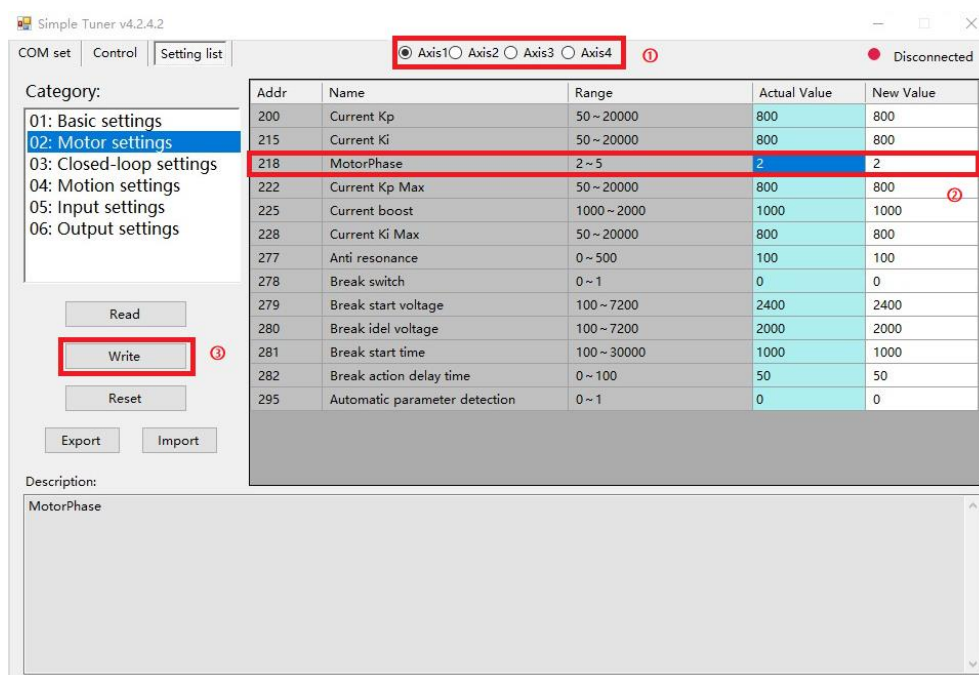
9. Motor Settings

This product supports two-phase, three-phase, and five phase motor connections. The default two-phase motor settings are provided at the factory. Please confirm the corresponding motor specifications of the current driver before connecting the motor to avoid motor burnout caused by incorrect motor connections.

9.1 Motor type setting

Confirmation before motor connection

Do not connect the motor. Check the motor settings inside the driver and ensure that the connected motor matches the settings inside the driver



Motor type description (note: pay attention to setting the motor type for each axis, do not omit)

- 2: Two phase motor
- 3: Three phase motor
- 5: Five phase motor

After successful setup, please power off and restart. After reconnecting to confirm that the motor settings are correct, you can proceed with the motor wiring operation.

9.2 Motor parameter settings

9.2.1 Parameters for open-loop motors

Class	Address	Parameter	Range	Default	Unit	Note
03	217	Motor mode	0~2	0	--	0: open loop, 1: closed loop.
01	241	Input Current	0~65535	1000	0.1%A	Motor Current
01	242	Set Subdivision File*	200~102400	10000	PPR	Divide
01	201	Motor Dir*	0~3	0		bit0 = 0 : Forward
						bit0 = 1 : Reverse
						Bit1 = 0 : Encoder Forward
						Bit1 = 1 : Encoder Reverse



Notes

The parameters marked in yellow need to be powered off and restarted after modification

When using an open-loop stepper motor, please follow the steps:

1. Connect the power to the driver and select the COM port to connect to the debugging software.
2. Set parameter 217 motor mode to 0, open loop mode
Set the input current of parameter 241 to the rated current of the motor
(refer to the phase current in the manual)
Set the sub level of parameter 242 to the number of pulses per revolution of the stepper motor.
After saving the parameters, power off the drive again.
3. Connect the motor to the driver, power on, and connect the debugging software.
4. Use parameter adjustment mode to jog and then stop, observe the direction of motor shaft operation and the system design direction requirements: If the direction of motor shaft operation is opposite to the system design direction requirements, modify parameter 201 to write 1.
After writing the 201 parameters to the drive, restarting is effective

9.2.2 Parameters for closed-loop motors

Class	Address	Parameter	Range	Default	Unit	Note
01	201	Motor Dir*	0~3	0		bit0 = 0 : Forward
						bit0 = 1 : Reverse
						Bit1 = 0 : Encoder Forward
						Bit1 = 1 : Encoder Reverse
01	241	Input Current	0~65535	1000	0.1%A	Motor Current
01	242	Set Subdivision*	200~102400	10000	PPR	Divide
03	217	Motor mode*	0~1	0		0: open-loop, 1: close-loop
03	246	Encoder resolution*	0~65535	4000	PPR	Encoder resolution
03	251	Speed loop KP	0~30000	1000		Kp
03	255	Position loop KP	0~30000	800		
03	258	Position deviation threshold	1~32000	1000		Max following error
03	264	KD filtering coefficient	0~1000	50		Kd
03	265	KD gain	0~1000	50		



Notes

The parameters marked in yellow need to be powered off and restarted after modification.

Adjustment steps for closed-loop stepper motor:

1. Connect the power to the driver, power on, and (select COM port) connect the debugging software.
2. Set parameter 217 motor mode to 0, open loop mode

Set the input current of parameter 241 to the rated current of the motor (refer to the phase current in the manual)

Set the sub level of parameter 242 to the number of pulses per revolution of the stepper motor.

Set encoder resolution in parameter 246

Set the out of tolerance threshold in parameter 258, which needs to be set according to the application situation.

After saving the parameters, power off the drive again.
3. Use the parameter adjustment mode to jog and then stop, observe the direction, actual position, and command position of the motor shaft:

Step 1: Observe whether there is data in the actual position,

If there is data, please skip to step 2

If there is no data, it indicates that the encoder signal is not effectively connected. Please check the encoder wiring definition and whether the connection is good.

Step 2: Observe whether the direction of mechanical operation is correct,

A. Correct:

Observe the actual position and instruction position values, and check if the positive and negative signs of the values are consistent,

Consistent: Write 0 for parameter 201

Inconsistent: 201 parameter written as 2

B. Incorrect:

Observe the actual position and instruction position values, and check if the positive and negative signs of the values are consistent,

Consistent: Write 1 for parameter 201

Inconsistent: 201 parameter written as 3

After modification, set the 217 parameter to 1 in closed-loop mode, then save the parameters and power on the driver again.

4. After re powering on, test run and observe the status of the motor or mechanism. Adjust the Kp parameter to adjust the motor rigidity. The larger the Kp parameter, the greater the rigidity. The higher the encoder resolution, the smaller the Kp parameter should be appropriately adjusted. The 251 and 255 parameters are generally adjusted synchronously. Adjusting Kd can improve overshoot and jitter issues. If the motor still cannot operate normally or its performance cannot meet the requirements after adjusting the above parameters, please consult technical support.

9.3 Signal pole settings

Default normally open signal

Simple Tuner v4.2.4.2

COM set | Control | Setting list

Axis1 Axis2 Axis3 Axis4

Disconnected

Category:

01: Basic settings
02: Motor settings
03: Closed-loop settings
04: Motion settings
05: Input settings
06: Output settings

Read
Write
Reset
Export Import

Addr	Name	Range	Actual Value	New Value
400	IN1 function	0 ~ 11	0	0
401	IN2 function	0 ~ 11	0	0
402	IN3 function	0 ~ 11	0	0
429	Input port logic	0 ~ 15	0	0

Description:
Input port logic, range:0 ~ 15, corresponding IN[4:1]: 0000 ~ 1111.

Example: Assuming that the input terminals of IN1 and IN2 are connected to normally closed signals, the corresponding binary 0B0000 0011 is converted to decimal 3, and the parameter settings are written to the driver as 3

10. Appendix : Homing Method

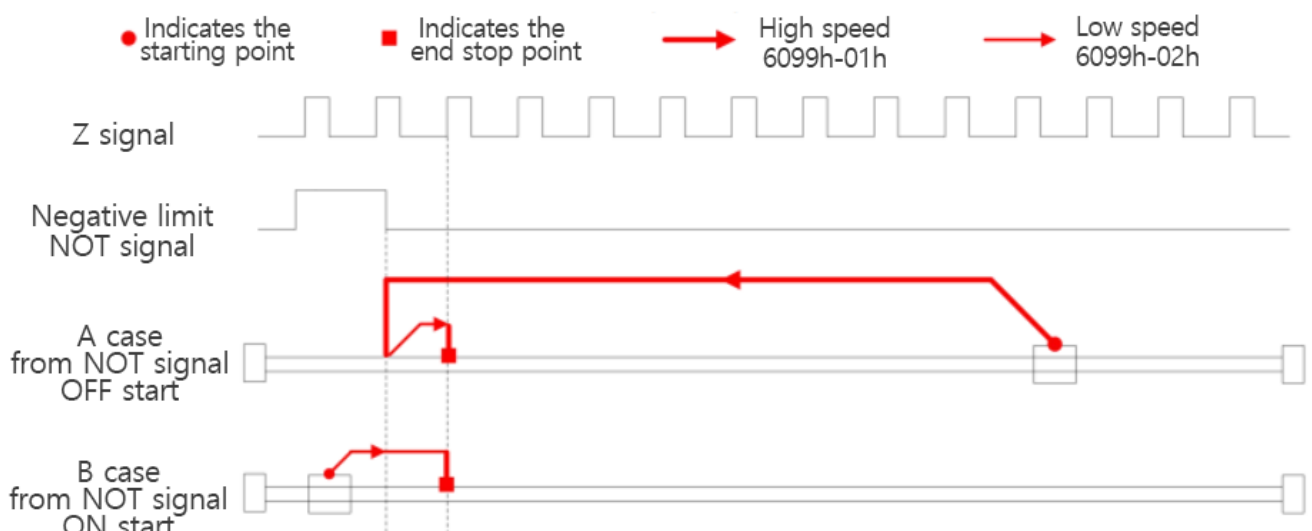
This driver product supports Z-signal return to origin methods of 1-14, 17-34, and 35. The specific definition and process of return to origin are described below.

Method 1:

If the negative limit is invalid, the motor will move at high speed towards the origin in the negative direction until the negative limit switch signal is valid. The motor will stop suddenly and start moving at low speed towards the origin in the forward direction. The first one after leaving the negative limit switch will stop moving when the encoder Z signal is valid, as shown in Figure A.

If the motor stops at the negative limit position when it starts moving at the origin, the motor will move forward at low speed at the origin and stop the first time after leaving the negative limit switch when the encoder Z signal is valid.

If the positive limit signal is valid during the movement, bit 13 of the status word (6041h) will be valid, indicating an error in the origin movement, and the motor will immediately stop.



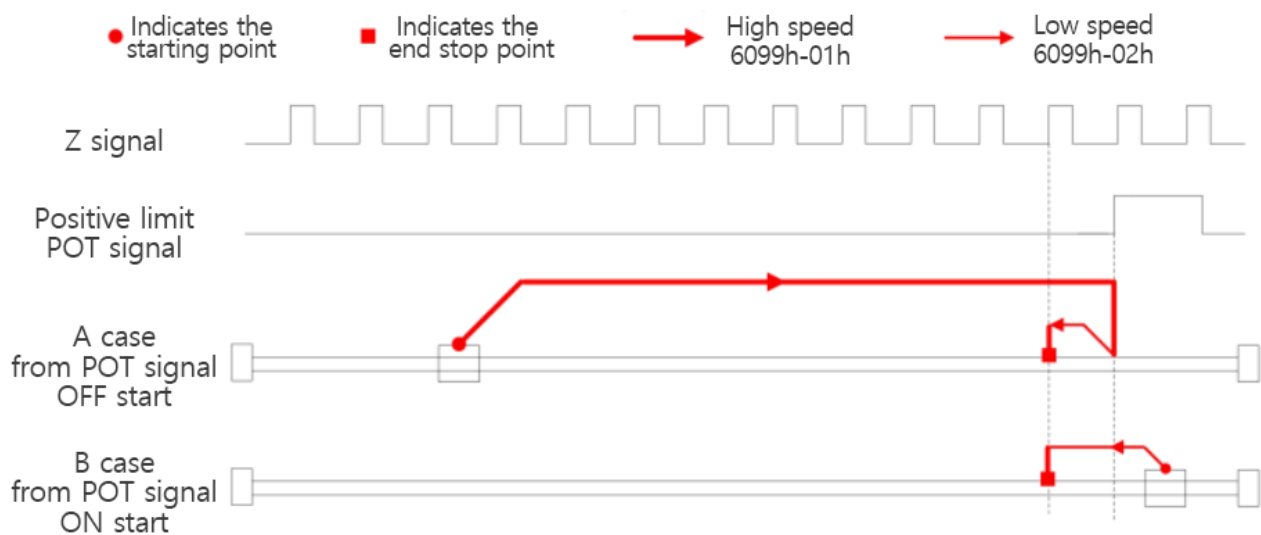
Method 1 Diagram

Method 2:

If the positive limit is invalid, the motor will move at high speed towards the origin in the positive direction until the positive limit switch signal is valid. The motor will stop and move at low speed towards the origin in the negative direction. When the first encoder Z signal after leaving the negative limit switch is valid, the motor will stop moving, as shown in Figure A.

If the motor stops at the positive limit position when it starts moving at the origin, the motor will move at low speed in the negative direction at the origin and stop when the first Z signal after leaving the positive limit switch is valid.

If the negative limit signal is valid during the movement process, bit 13 of the status word (6041h) will be valid, indicating an error in the origin movement, and the motor will immediately stop.



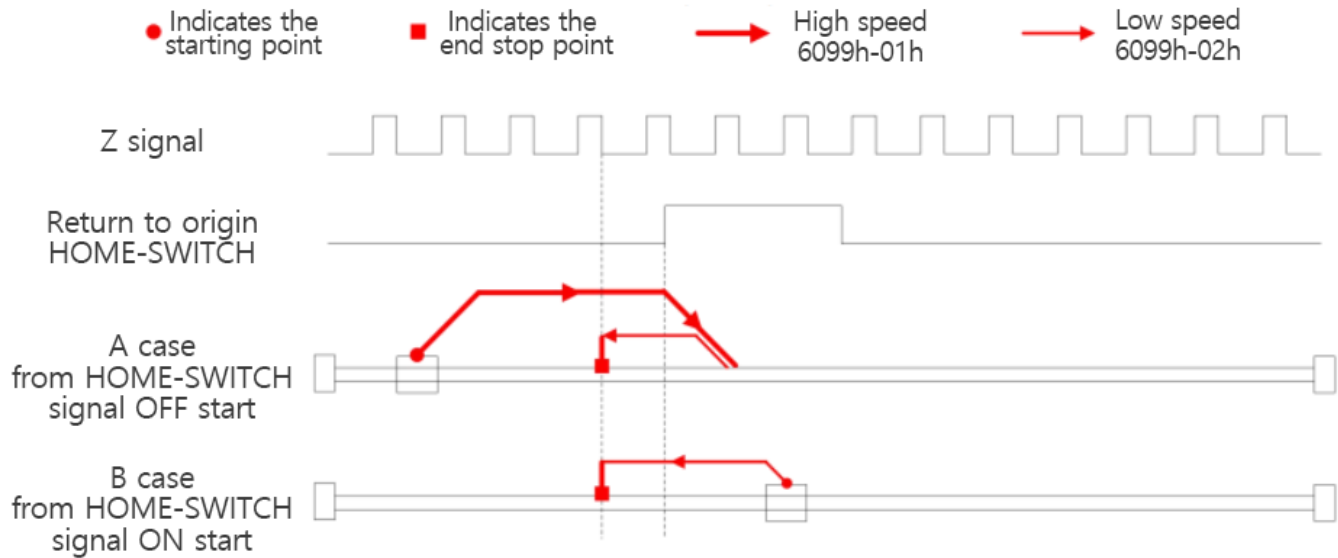
Method 2 Diagram

Method 3:

If the origin signal is invalid, the motor will move at high speed in the positive direction until the origin signal is valid. The motor will stop and move at low speed in the negative direction until the first encoder Z signal after leaving the origin switch is valid, as shown in Figure A.

If the motor stops at the origin signal switch position when it starts moving at the origin, the motor will move at low speed in the negative direction at the origin and stop when the first Z signal after leaving the origin switch is valid.

If the limit signal is valid during the movement, bit 13 of the status word (6041h) will be valid, indicating an error in the origin movement, and the motor will immediately stop.



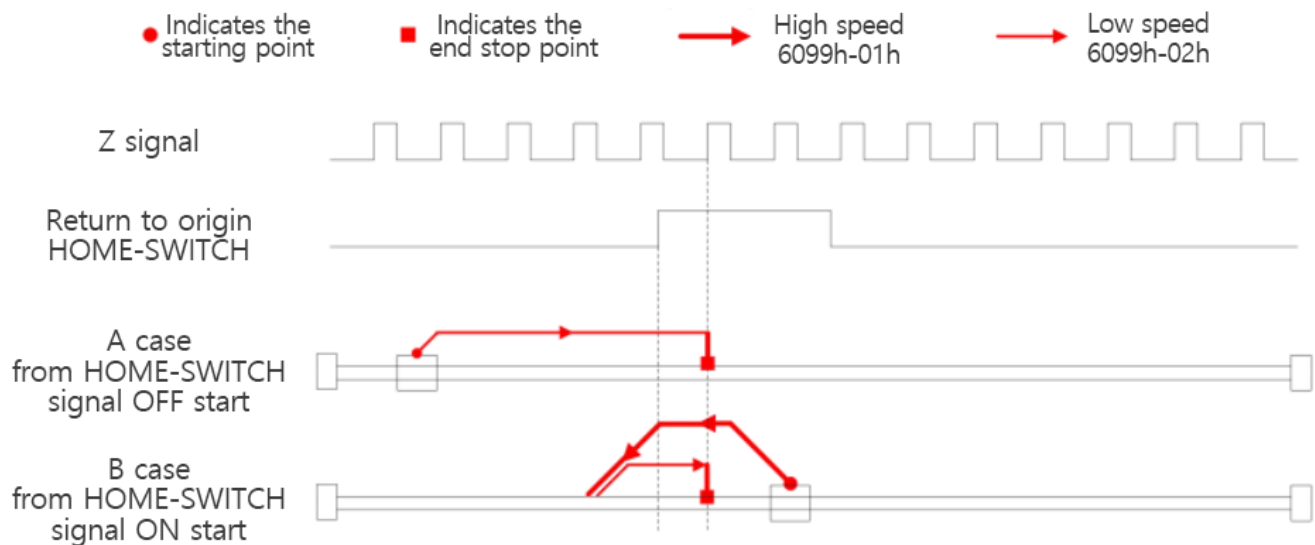
Method 3 Diagram

Method 4:

If the origin signal is invalid, the motor will move forward at low speed at the origin until the first encoder Z signal after the origin signal is valid stops, as shown in Figure 7-4.

If the motor stops at the position of the origin signal switch when it starts moving at the origin, the motor will move at high speed in the negative direction until the origin signal is invalid. The motor will slow down and stop moving at low speed in the positive direction until the first encoder Z signal after the origin signal is valid stops moving, as shown in Figure B.

If the limit signal is valid during the movement, bit 13 of the status word (6041h) will be valid, indicating an error in the origin movement, and the motor will immediately stop.



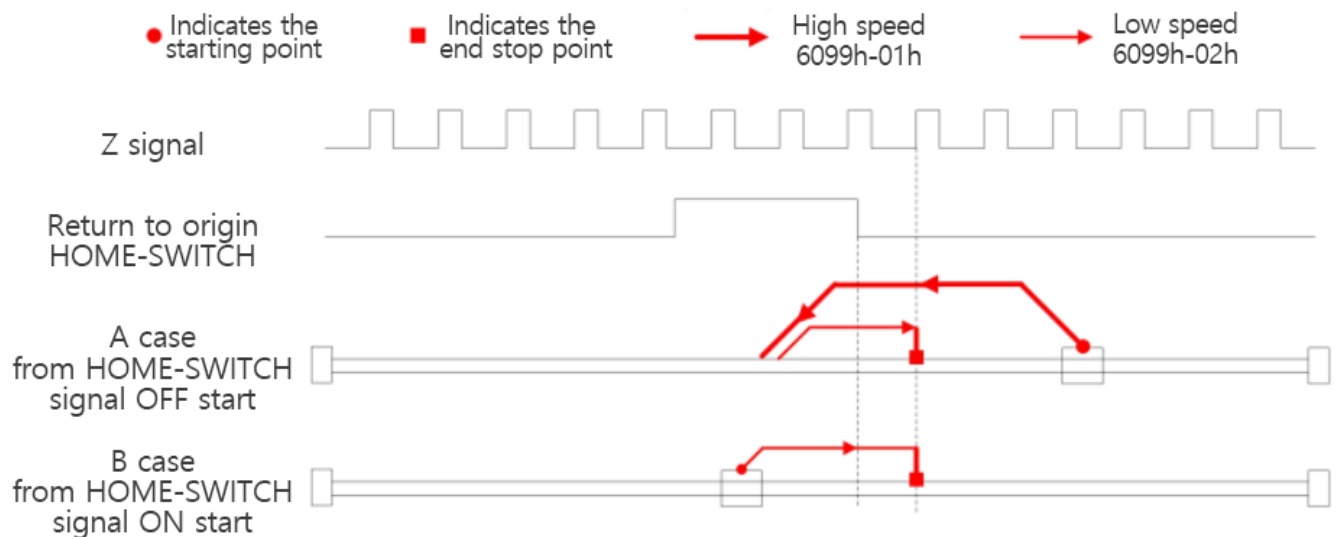
Method 4 Diagram

Method 5:

If the origin signal is invalid, the motor will move at high speed in the negative direction until the origin signal is valid. After the motor slows down and stops, it will move at low speed in the positive direction until the first encoder Z signal after leaving the origin signal switch is valid, as shown in Figure A.

If the motor stops at the position of the origin signal switch when it starts moving at the origin, the motor will move forward at low speed at the origin and stop when the first Z signal after leaving the origin signal switch is valid, as shown in Figure B.

If the limit signal is valid during the movement, bit 13 of the status word (6041h) will be valid, indicating an error in the origin movement, and the motor will immediately stop.



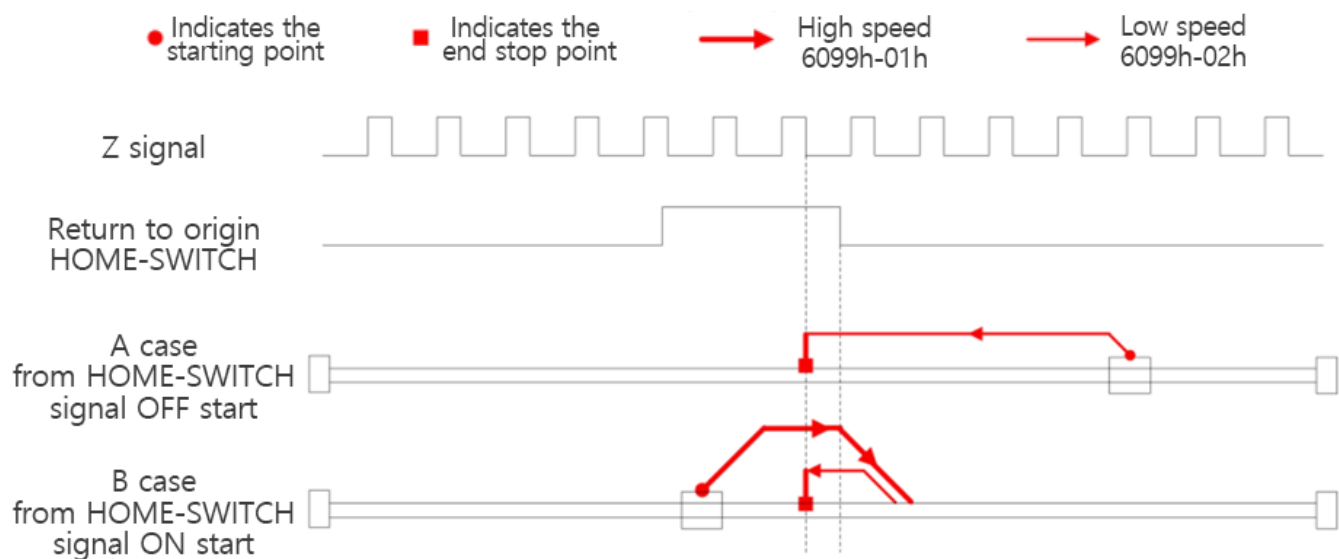
Method 5 Diagram

Methods 6:

If the origin signal is invalid, the motor will move at low speed towards the origin in the negative direction until the first encoder Z signal with valid origin signal stops moving, as shown in Figure A.

If the motor stops at the position of the origin signal switch when it starts moving at the origin, the motor will move forward at high speed at the origin, slow down and stop when it leaves the origin signal switch, and then move in the opposite direction at low speed at the origin until the first Z signal with valid origin signal stops, as shown in Figure B.

If the limit signal is valid during the movement, bit 13 of the status word (6041h) will be valid, indicating an error in the origin movement, and the motor will immediately stop.



Method 6 Diagram

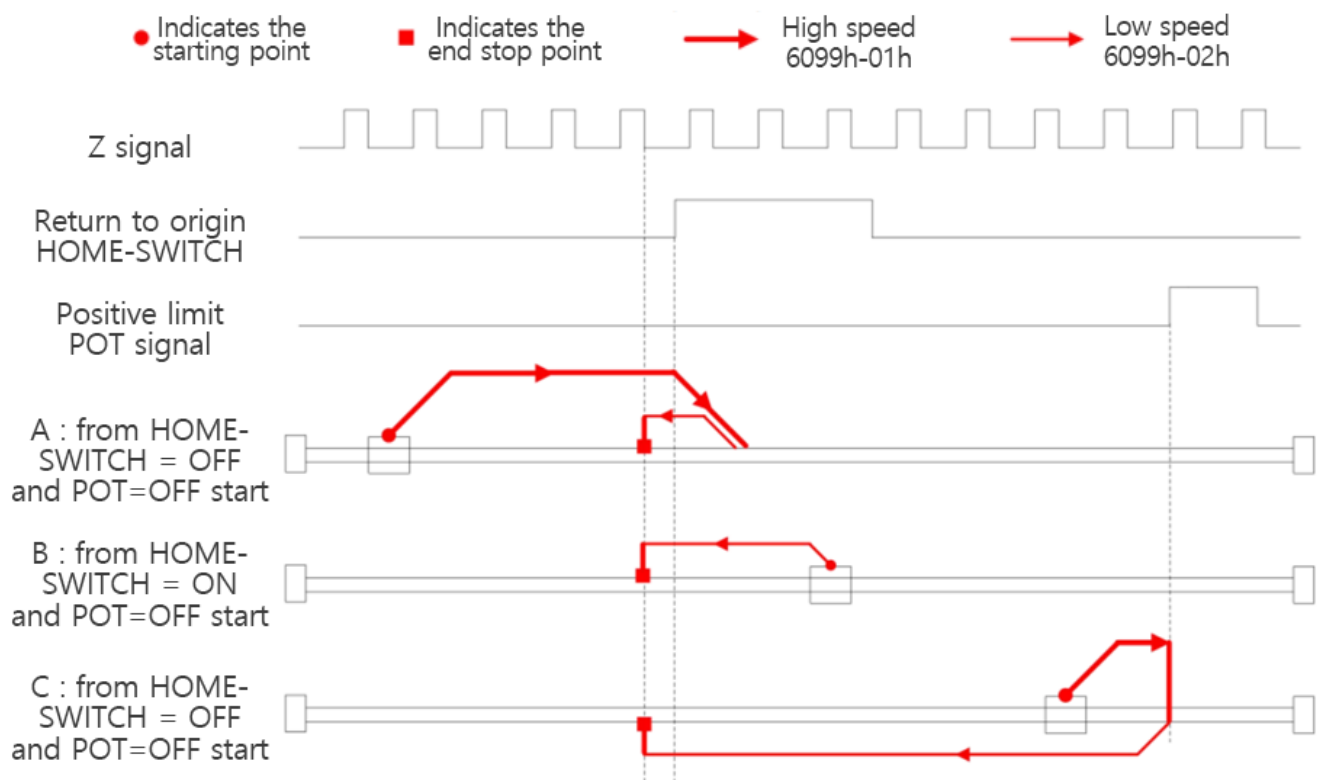
Methods 7:

If both the origin signal and the positive limit signal are invalid, the motor will move at high speed towards the origin in the positive direction until the origin signal is valid and decelerates to stop. Then, it will move at low speed towards the origin in the negative direction and stop moving when the first encoder Z signal leaving the origin signal switch is valid, as shown in Figure A.

If the positive limit is invalid, the motor will stop at the origin signal switch position when it starts moving at the origin. The motor will move at low speed in the negative direction at the origin and stop when the first Z signal leaving the origin signal switch is valid, as shown in Figure B.

If both the origin signal and the positive limit signal are invalid, the motor will move forward at high speed at the origin until the positive limit signal is effective and emergency stop is achieved. Then, it will move at low speed at the origin in the negative direction and continue to move until the first encoder Z signal that leaves the origin signal switch is effective and stops moving, as shown in Figure C.

If the negative limit signal is valid during the movement, bit 13 of the status word (6041h) will be valid, indicating an error in the origin movement and the motor will immediately stop.



Method 7 Diagram

Methods 8:

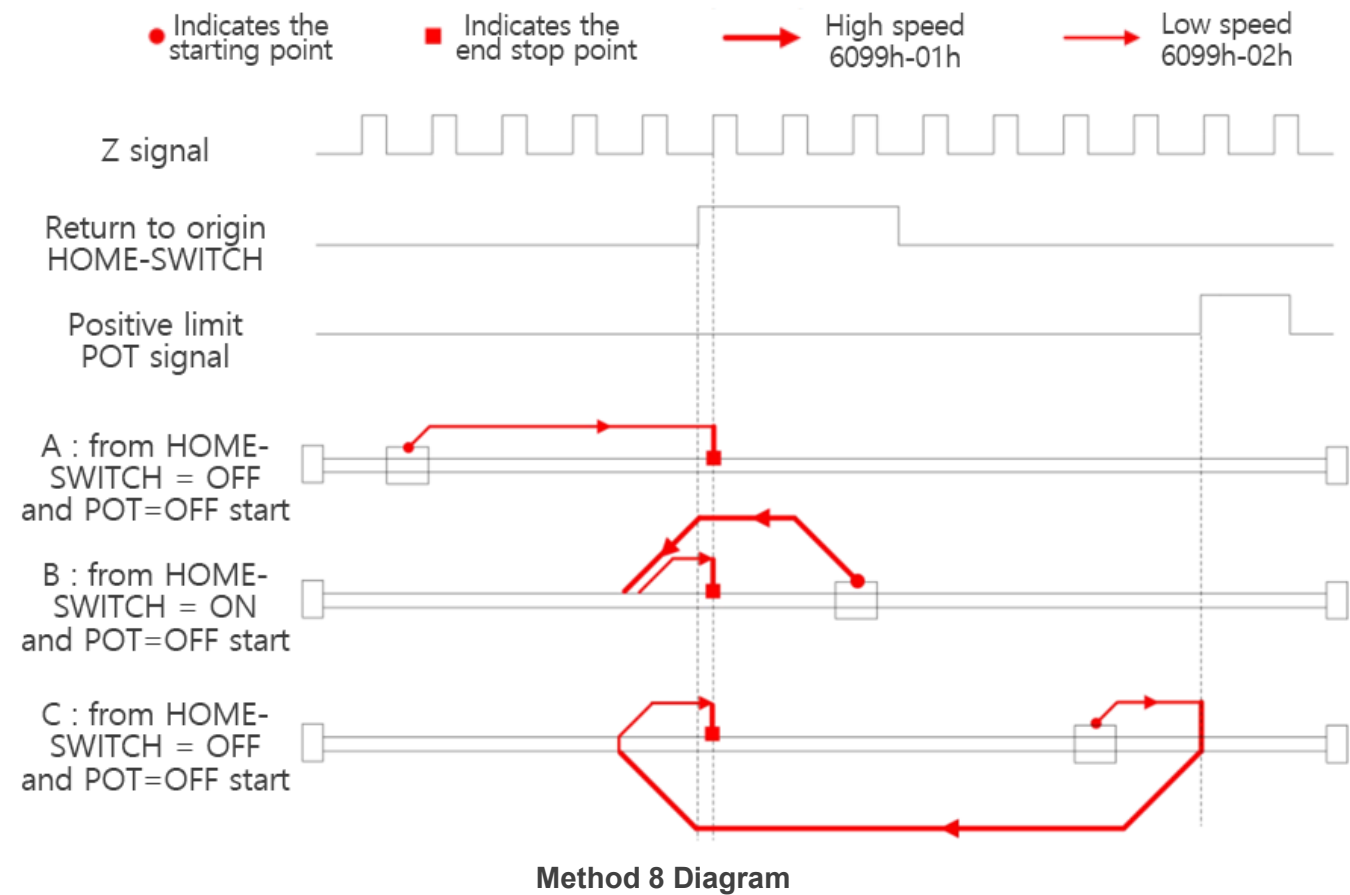
If both the origin signal and the positive limit signal are invalid, the motor will move at low speed towards the origin in the positive direction, and stop moving when the first encoder Z signal with valid origin signal is valid, as shown in Figure A.

If the positive limit is invalid, the motor will stop at the position of the origin signal switch when it starts

moving at the origin. The motor will move at high speed in the negative direction at the origin, slow down and stop after leaving the origin signal switch, and then move forward at low speed at the origin. It will stop when the first Z signal after the origin signal is valid, as shown in Figure B.

If both the origin signal and the positive limit signal are invalid, the motor will move forward at low speed at the origin until the positive limit signal is effective and the emergency stop is reached. Then, it will move at high speed at the origin in the negative direction and continue to move until it leaves the origin signal switch and decelerates to stop. Then, it will move forward at low speed at the origin and stop moving when the first encoder Z signal after the origin signal is effective, as shown in Figure C.

If the negative limit signal is valid during the movement, bit 13 of the status word (6041h) will be valid, indicating an error in the origin movement and the motor will immediately stop.



Methods 9:

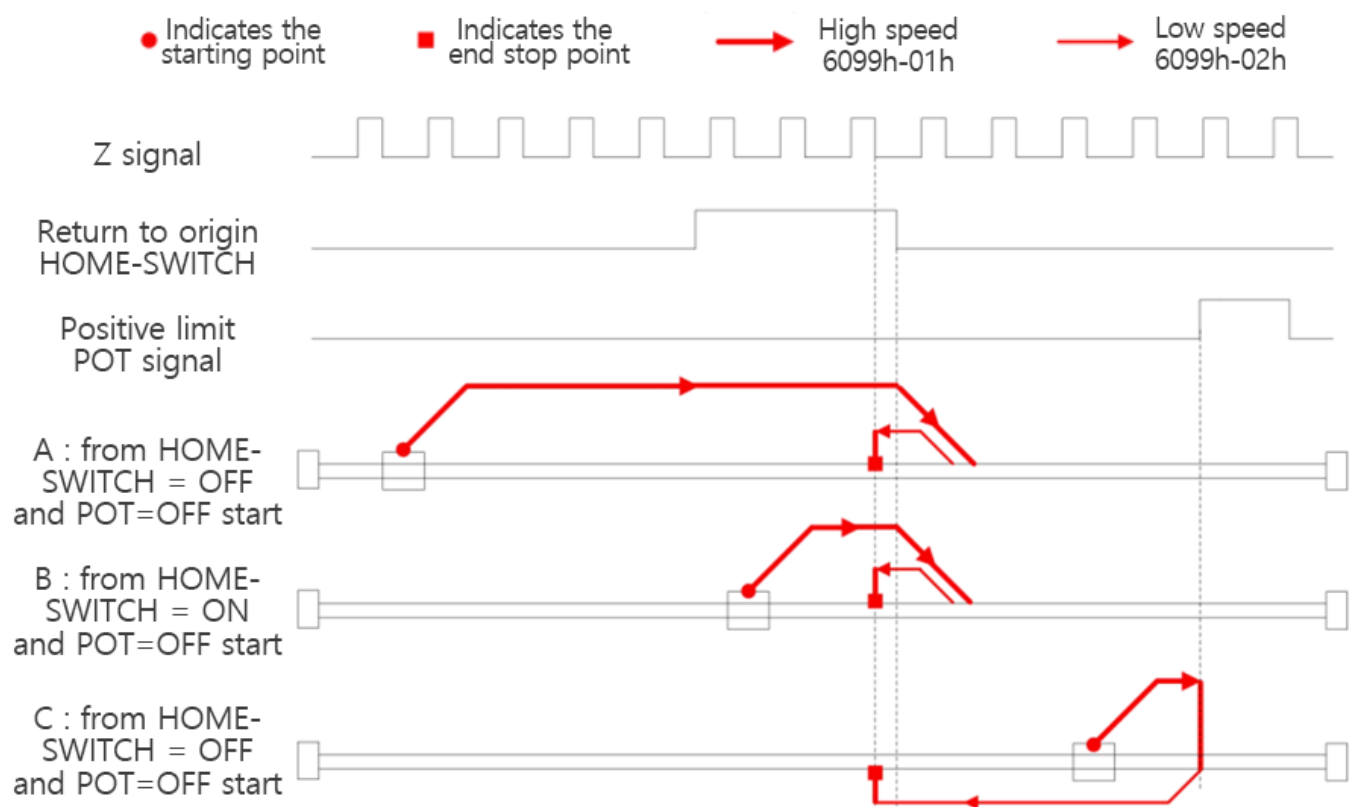
If both the origin signal and the positive limit signal are invalid, the motor will move at high speed towards the origin in the positive direction. When the origin signal is valid, it will continue to move. When it leaves the origin signal switch, it will slow down and stop. Then, it will move at low speed towards the origin in the negative direction until the first encoder Z signal after the origin signal is valid stops moving, as shown in Figure A.

If the positive limit is invalid, the motor will stop at the origin signal switch position when it starts moving

at the origin. The motor will move at high speed in the forward direction at the origin, slow down and stop after leaving the origin signal switch, and then move at low speed at the origin in the negative direction. It will stop when the first Z signal after the origin signal is valid, as shown in Figure B.

If both the origin signal and the positive limit signal are invalid, the motor will move forward at high speed at the origin until the positive limit signal is effective and emergency stop is achieved. Then, it will move at low speed at the origin in the negative direction and stop moving when the first encoder Z signal after the origin signal is effective, as shown in Figure C.

If the negative limit signal is valid during the movement, bit 13 of the status word (6041h) will be valid, indicating an error in the origin movement and the motor will immediately stop.



Method 9 Diagram

Methods 10:

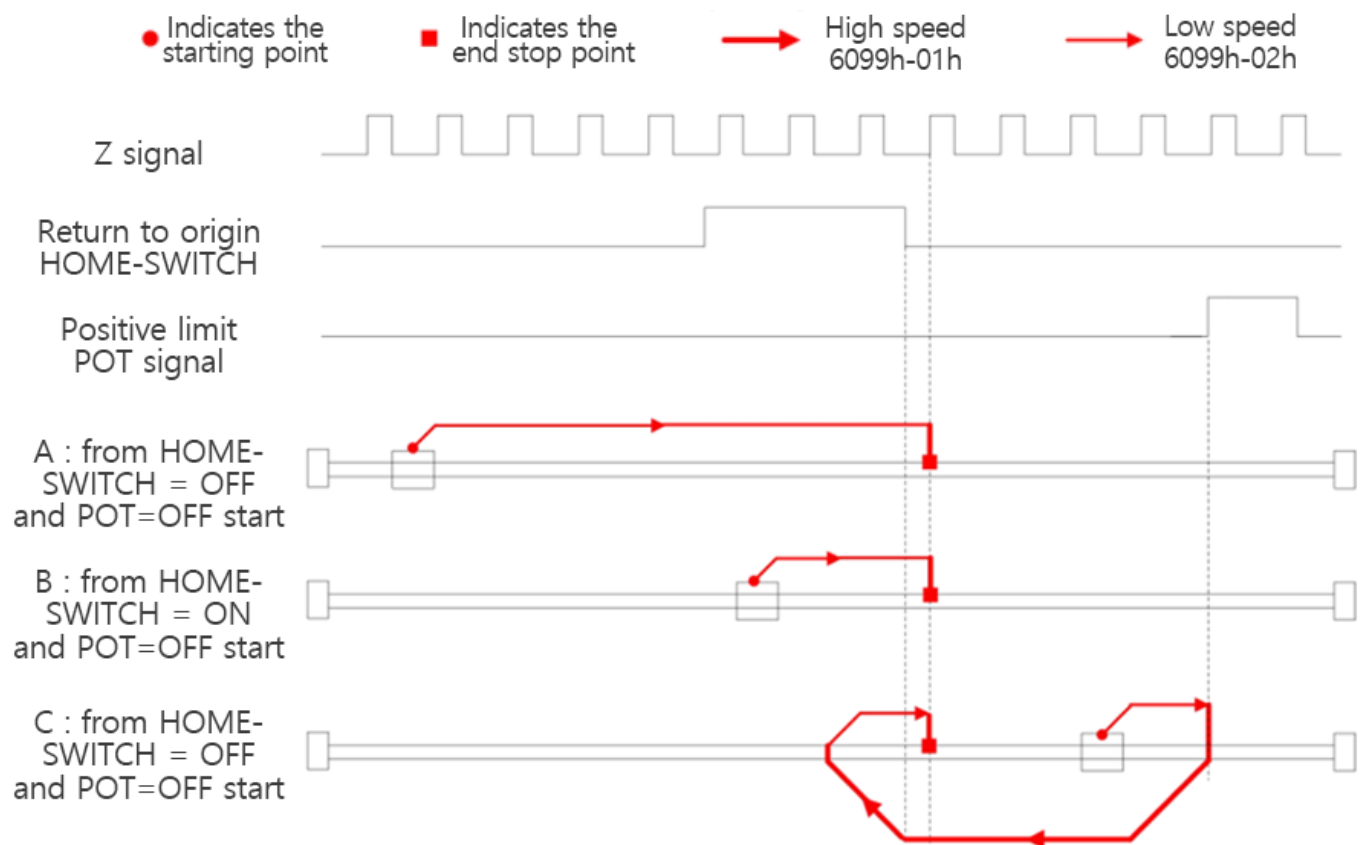
If both the origin signal and the positive limit signal are invalid, the motor will move at low speed towards the origin in the positive direction. When the origin signal is valid, it will continue to move until the first encoder Z signal after the origin signal is invalid stops moving, as shown in Figure A.

If the positive limit is invalid, the motor will stop at the position of the origin signal switch when it starts moving at the origin. The motor will move forward at low speed at the origin and stop when the first Z signal is valid after the origin signal is invalid, as shown in Figure B.

If both the origin signal and the positive limit signal are invalid, the motor will move forward at low speed

at the origin until the positive limit signal is valid and then stop abruptly. It will then move at high speed at the origin in the negative direction, slow down and stop when the origin signal is valid, and then move forward at low speed at the origin until the first encoder Z signal after the origin signal is invalid and stops moving, as shown in Figure C.

If the negative limit signal is valid during the movement, bit 13 of the status word (6041h) will be valid, indicating an error in the origin movement and the motor will immediately stop.



Method 10 Diagram

Methods 11

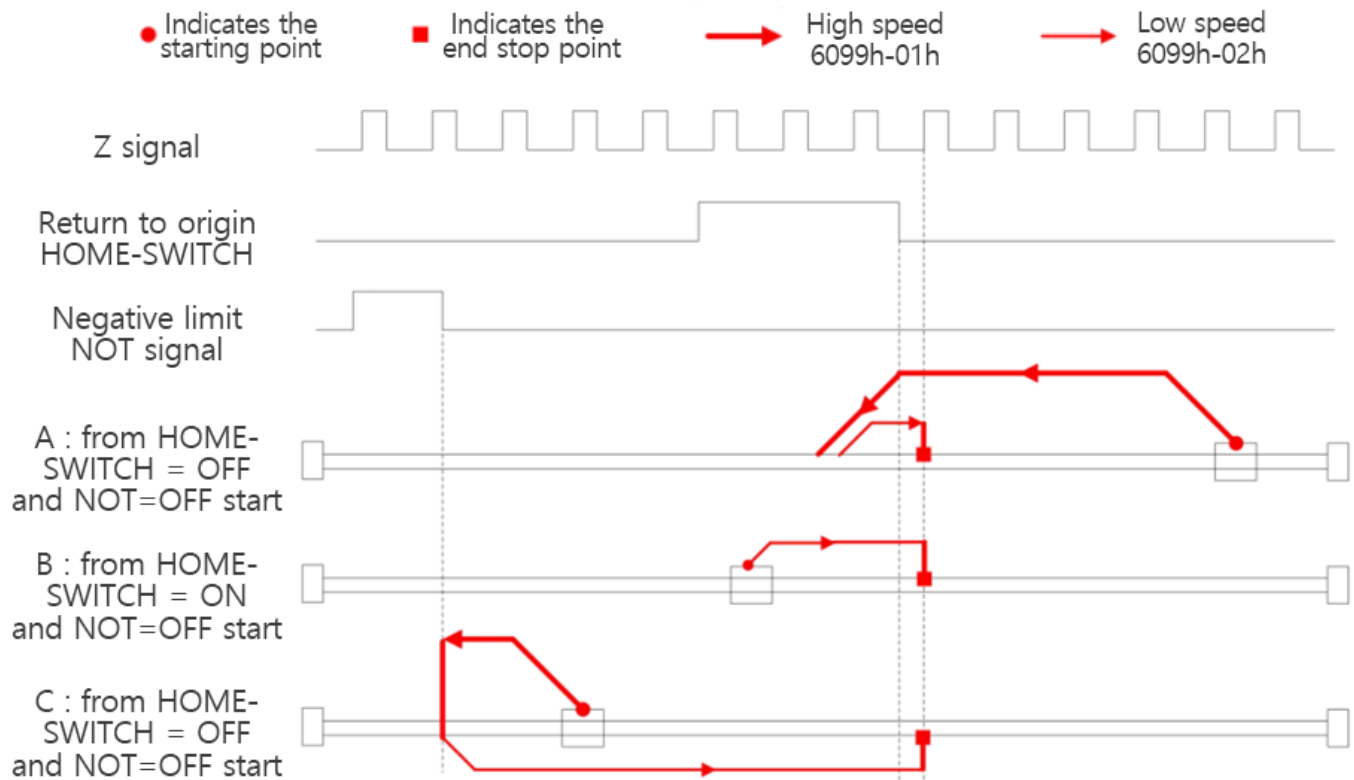
If both the origin signal and the negative limit signal are invalid, the motor will move at high speed towards the origin in the negative direction until the origin signal is valid, then decelerate and stop. Then, it will move at low speed towards the origin in the positive direction, and stop moving when the first encoder Z signal leaving the origin signal switch is valid, as shown in Figure A.

If the negative limit is invalid, the motor will stop at the origin signal switch position when it starts moving at the origin. The motor will move forward at low speed at the origin and stop when the first Z signal leaving the origin signal switch is valid, as shown in Figure B.

If both the origin signal and negative limit signal are invalid, the motor will move at high speed towards the origin in the negative direction until the negative limit signal is effective and emergency stop is achieved. Then, it will move at low speed towards the origin in the positive direction and continue to

move until the first encoder Z signal that leaves the origin signal switch is effective and stops moving, as shown in Figure C.

If the positive limit signal is valid during the movement, bit 13 of the status word (6041h) will be valid, indicating an error in the origin movement, and the motor will immediately stop.



Method 11 Diagram

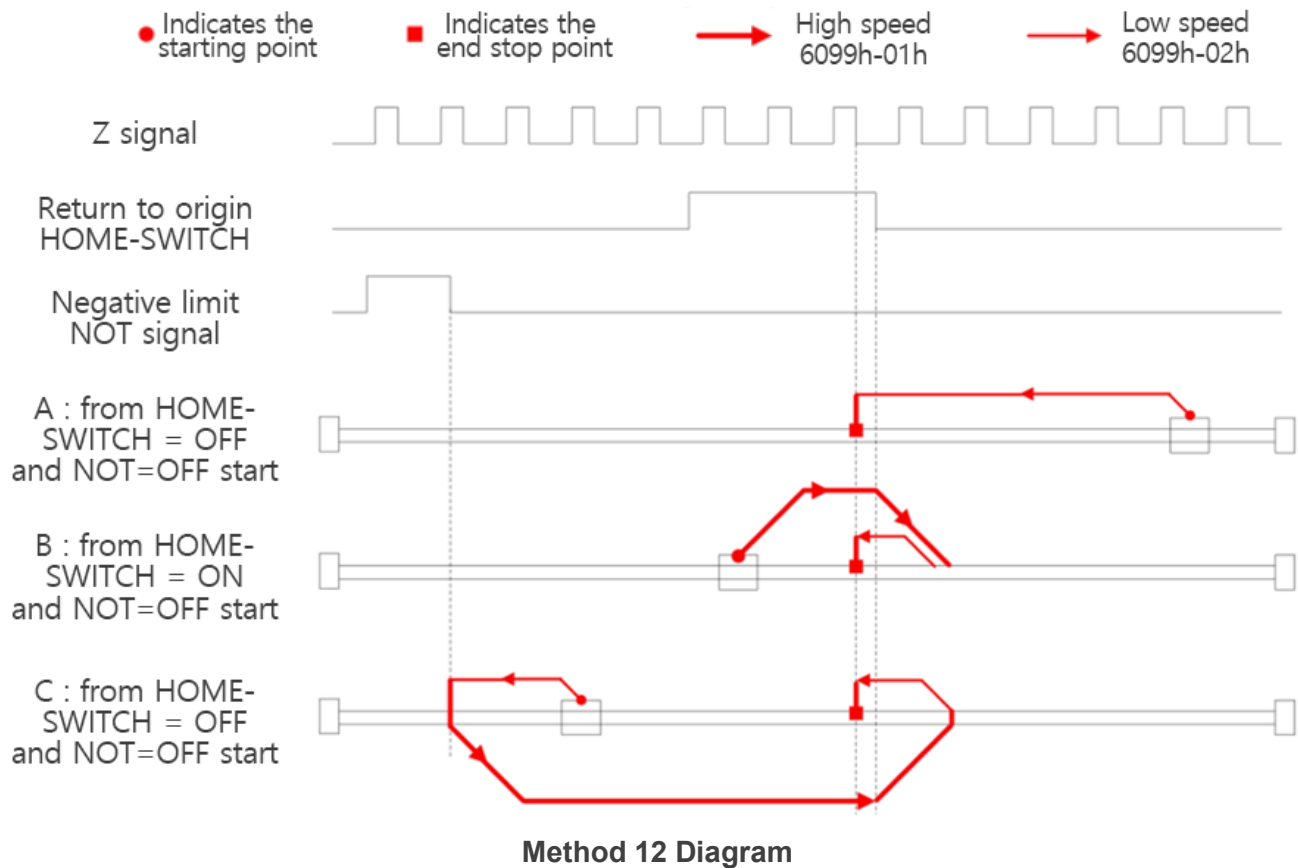
Methods 12:

If both the origin signal and the negative limit signal are invalid, the motor will move at high speed towards the origin in the negative direction until the origin signal is valid, then decelerate and stop. Then, it will move at low speed towards the origin in the positive direction, and stop moving when the first encoder Z signal leaving the origin signal switch is valid, as shown in Figure A.

If the negative limit is invalid, the motor will stop at the origin signal switch position when it starts moving at the origin. The motor will move forward at low speed at the origin and stop when the first Z signal leaving the origin signal switch is valid, as shown in Figure B.

If both the origin signal and negative limit signal are invalid, the motor will move at high speed towards the origin in the negative direction until the negative limit signal is effective and emergency stop is achieved. Then, it will move at low speed towards the origin in the positive direction and continue to move until the first encoder Z signal that leaves the origin signal switch is effective and stops moving, as shown in Figure C.

If the positive limit signal is valid during the movement, bit 13 of the status word (6041h) will be valid, indicating an error in the origin movement, and the motor will immediately stop.



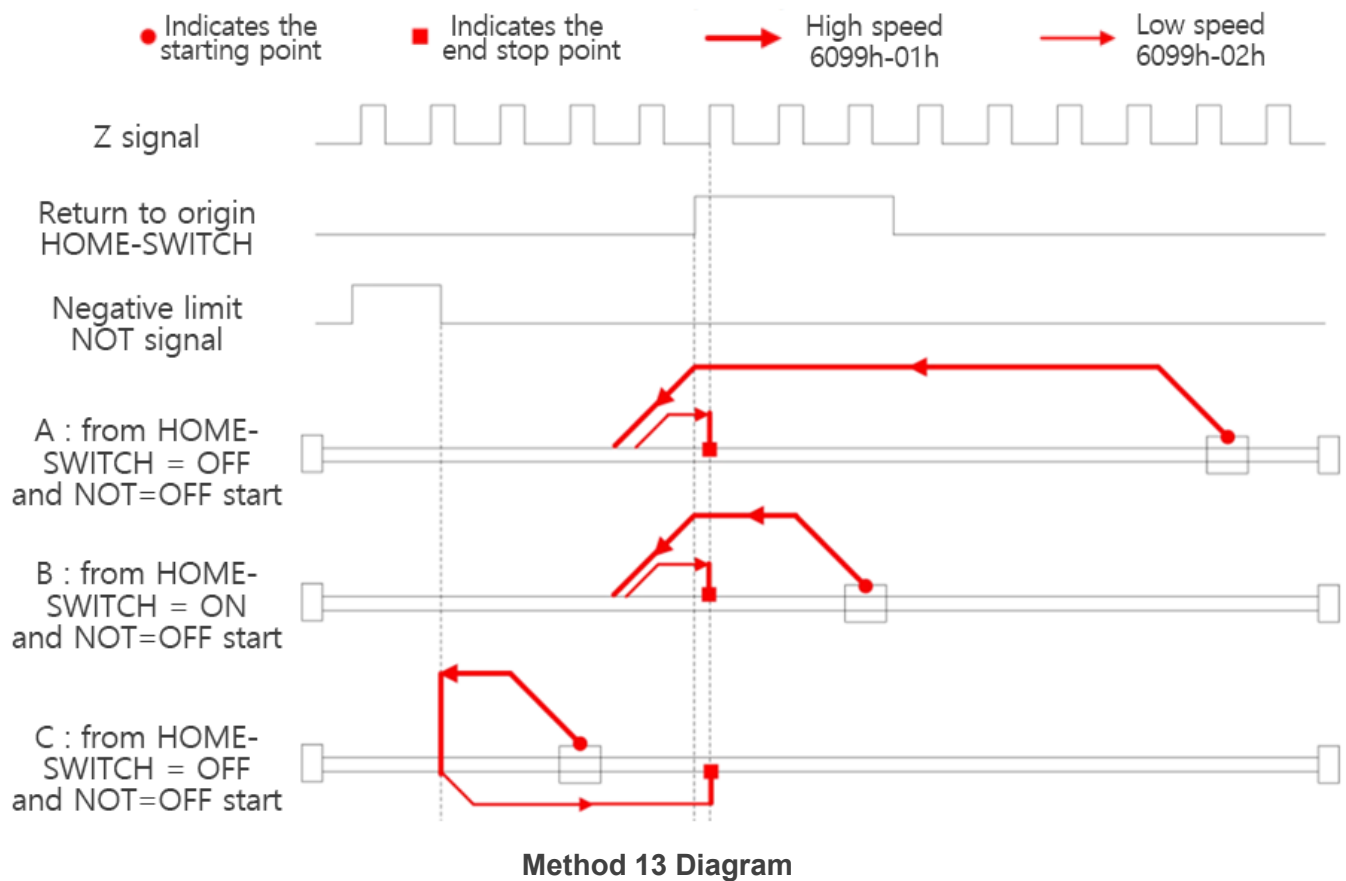
Methods 13:

If both the origin signal and negative limit signal are invalid, the motor will move at high speed towards the origin in the negative direction. When the origin signal is valid, it will continue to move. When leaving the origin signal switch, it will slow down and stop. Then, it will move at low speed towards the origin in the positive direction until the first encoder Z signal after the origin signal is valid stops moving, as shown in Figure A.

If the negative limit is invalid, the motor will stop at the origin signal switch position when it starts moving at the origin. The motor will move at high speed in the negative direction at the origin, slow down and stop after leaving the origin signal switch, and then move forward at low speed at the origin. It will stop when the first Z signal after the origin signal is valid, as shown in Figure B.

If both the origin signal and the negative limit signal are invalid, the motor will move at high speed towards the origin in the negative direction until the negative limit signal is valid and stops abruptly. Then, it will move at low speed towards the origin in the positive direction until the first encoder Z signal after the origin signal is valid and stops moving, as shown in Figure C.

If the negative limit signal is valid during the movement, bit 13 of the status word (6041h) will be valid, indicating an error in the origin movement and the motor will immediately stop.



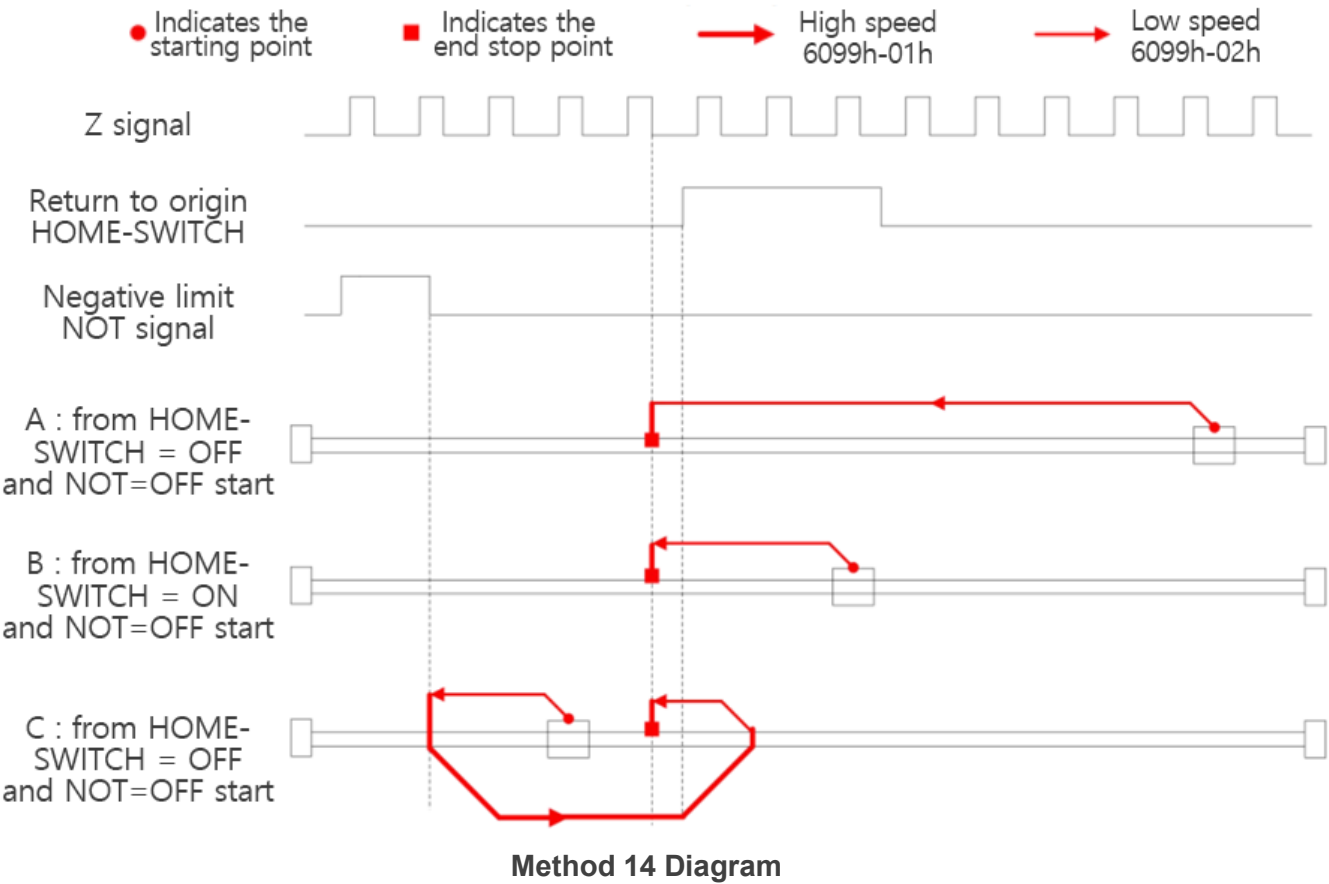
Methods 14:

If both the origin signal and negative limit signal are invalid, the motor will move at low speed towards the origin in the negative direction. When the origin signal is valid, it will continue to move until the first encoder Z signal after the origin signal is invalid stops moving, as shown in Figure A.

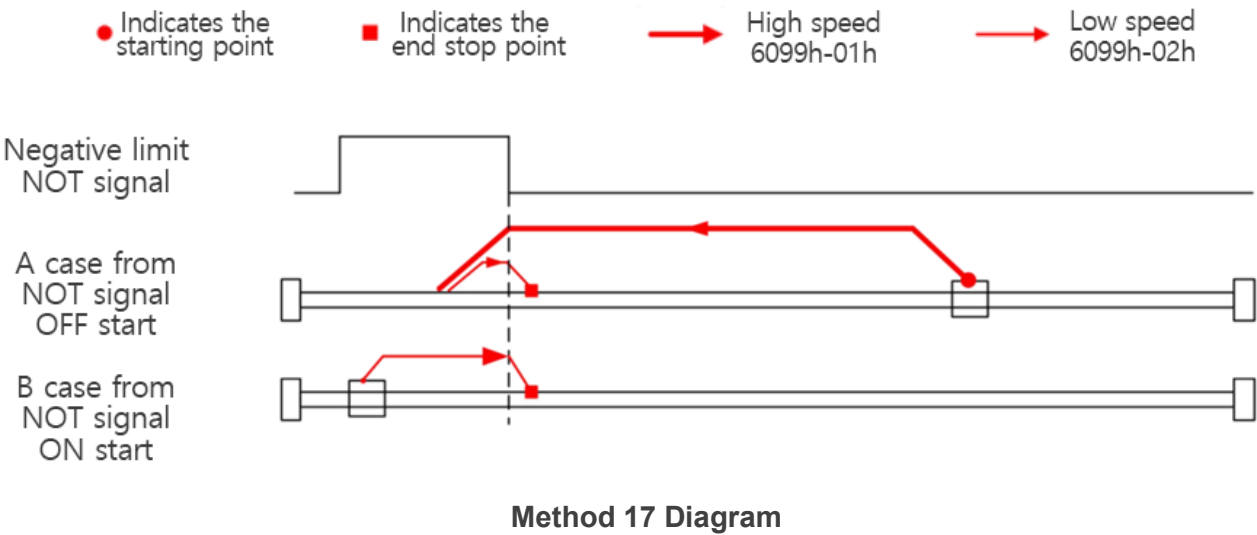
If the negative limit is invalid, the motor will stop at the position of the origin signal switch when it starts moving at the origin. The motor will move at a low speed in the negative direction at the origin, and stop when the first Z signal is valid after the origin signal is invalid, as shown in Figure B.

If both the origin signal and negative limit signal are invalid, the motor will move at low speed towards the origin in the negative direction until the negative limit signal is valid and then stop abruptly. It will then move at high speed towards the origin in the positive direction, slow down and stop when the origin signal is valid, and then move at low speed towards the origin in the negative direction until the first encoder Z signal after the origin signal is invalid and stops moving, as shown in Figure C.

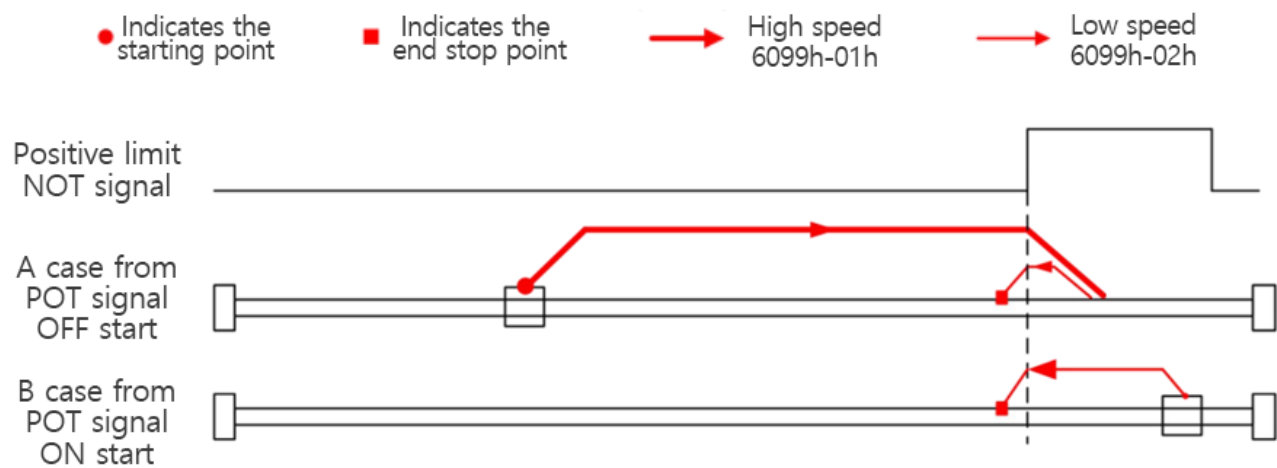
If the negative limit signal is valid during the movement, bit 13 of the status word (6041h) will be valid, indicating an error in the origin movement and the motor will immediately stop.



Methods 17:

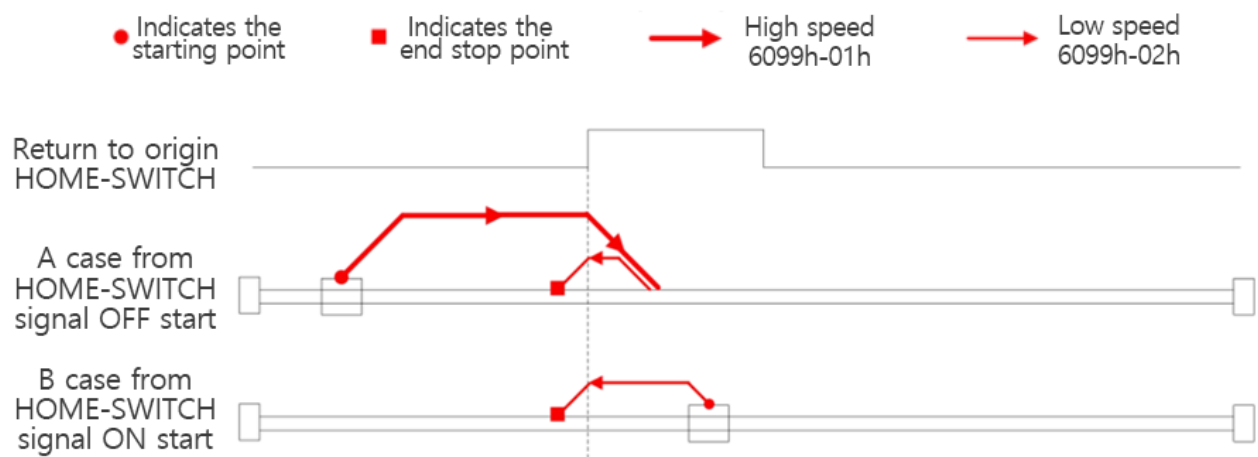


Method 18:



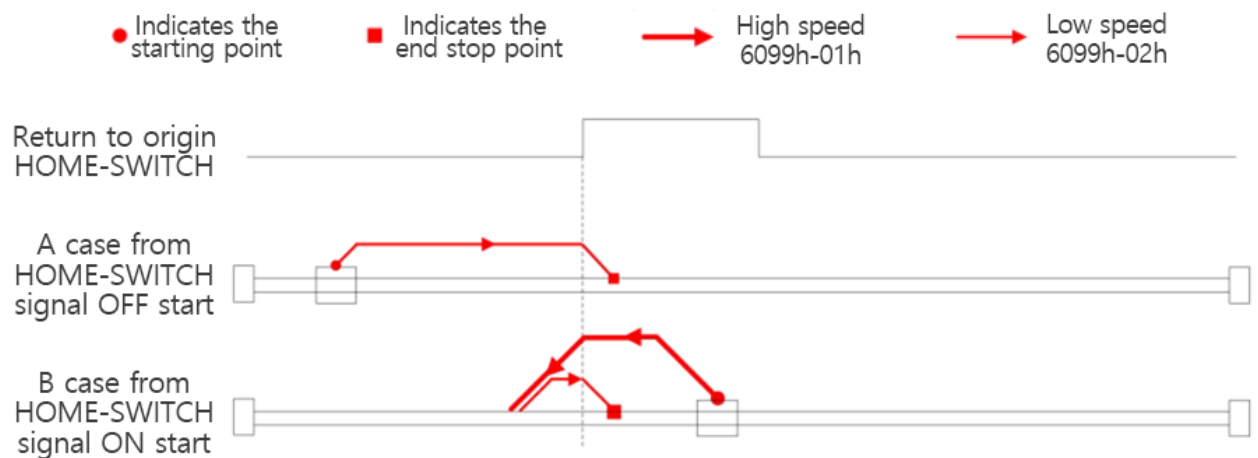
Method 18 Diagram

Method 19:



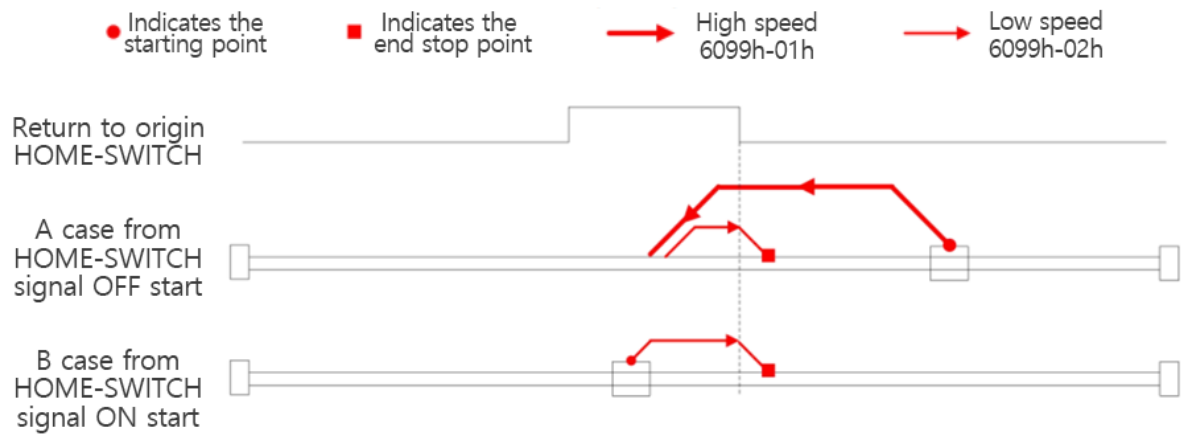
Method 19 Diagram

Method 20:



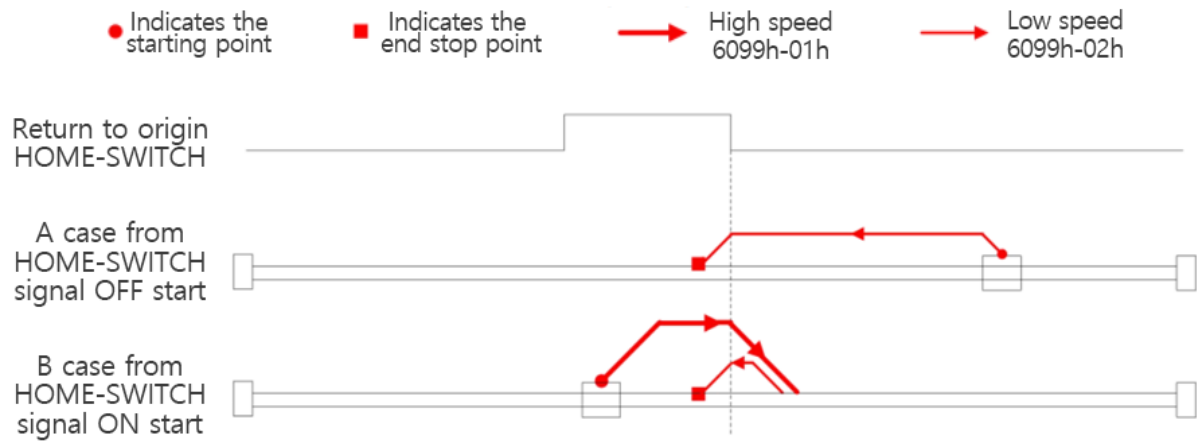
Method 20 Diagram

Method 21:



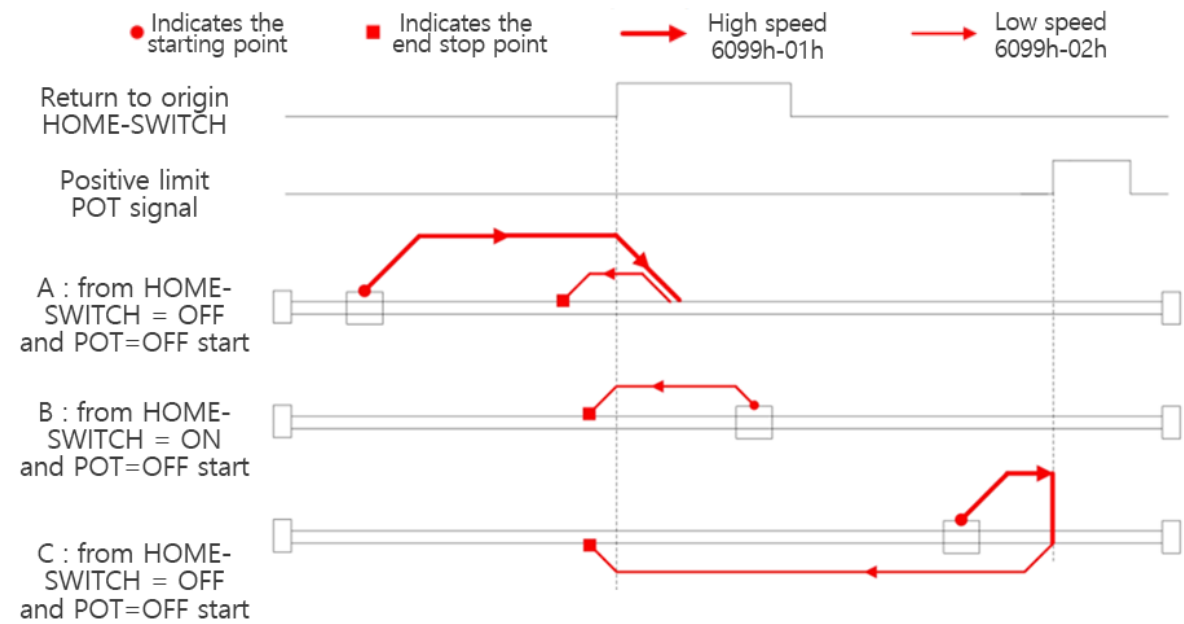
Method 21 Diagram

Method 22:



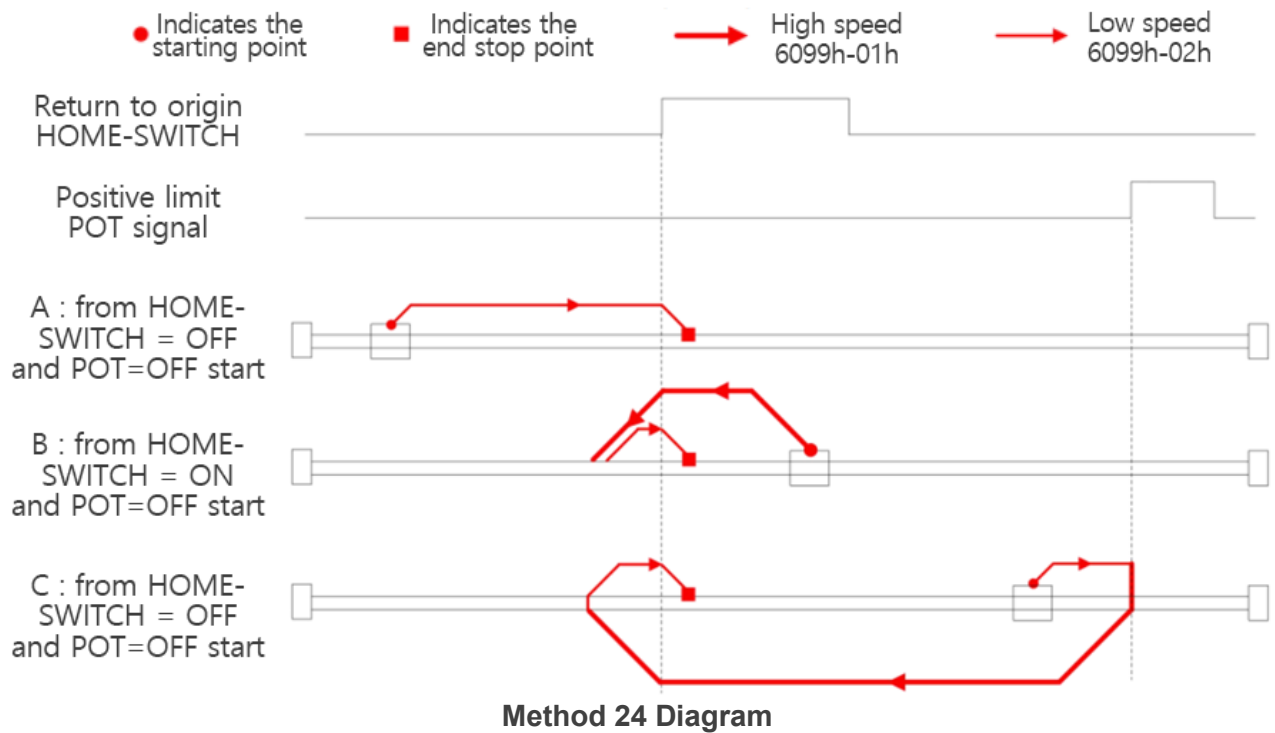
Method 22 Diagram

Method 23:

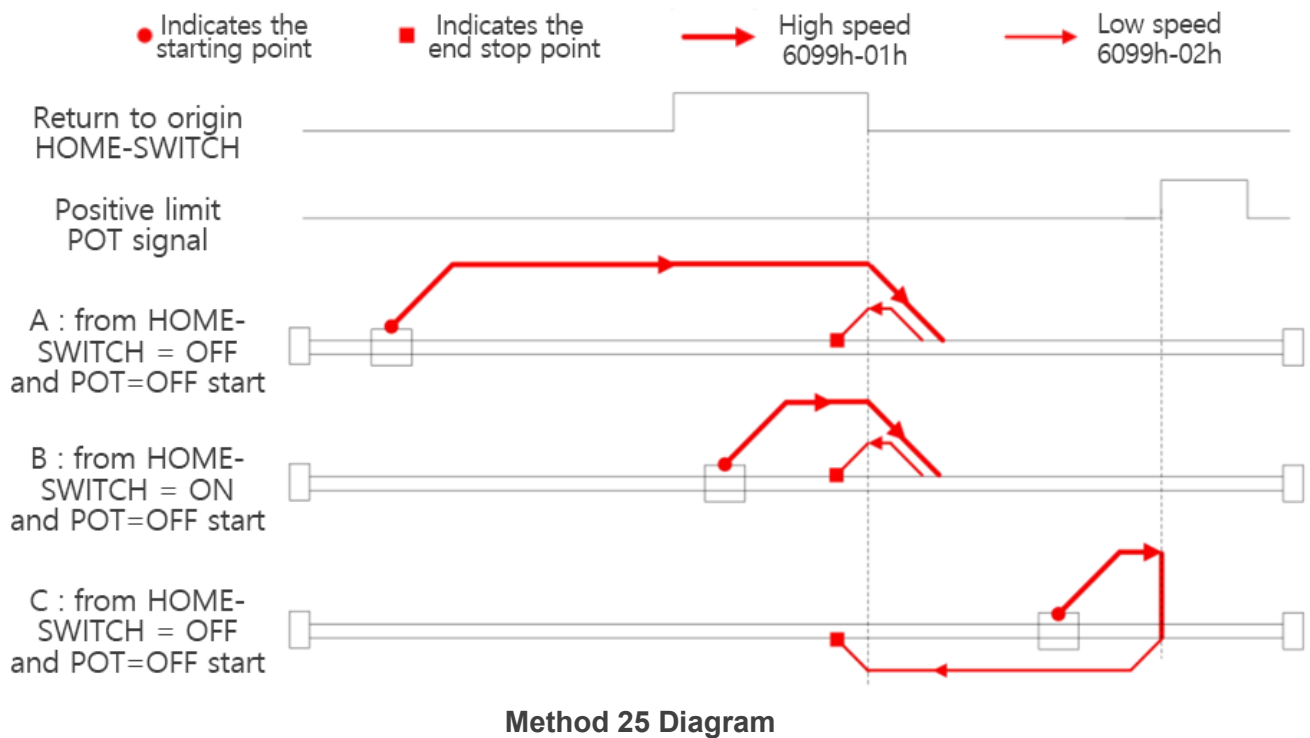


Method 23 Diagram

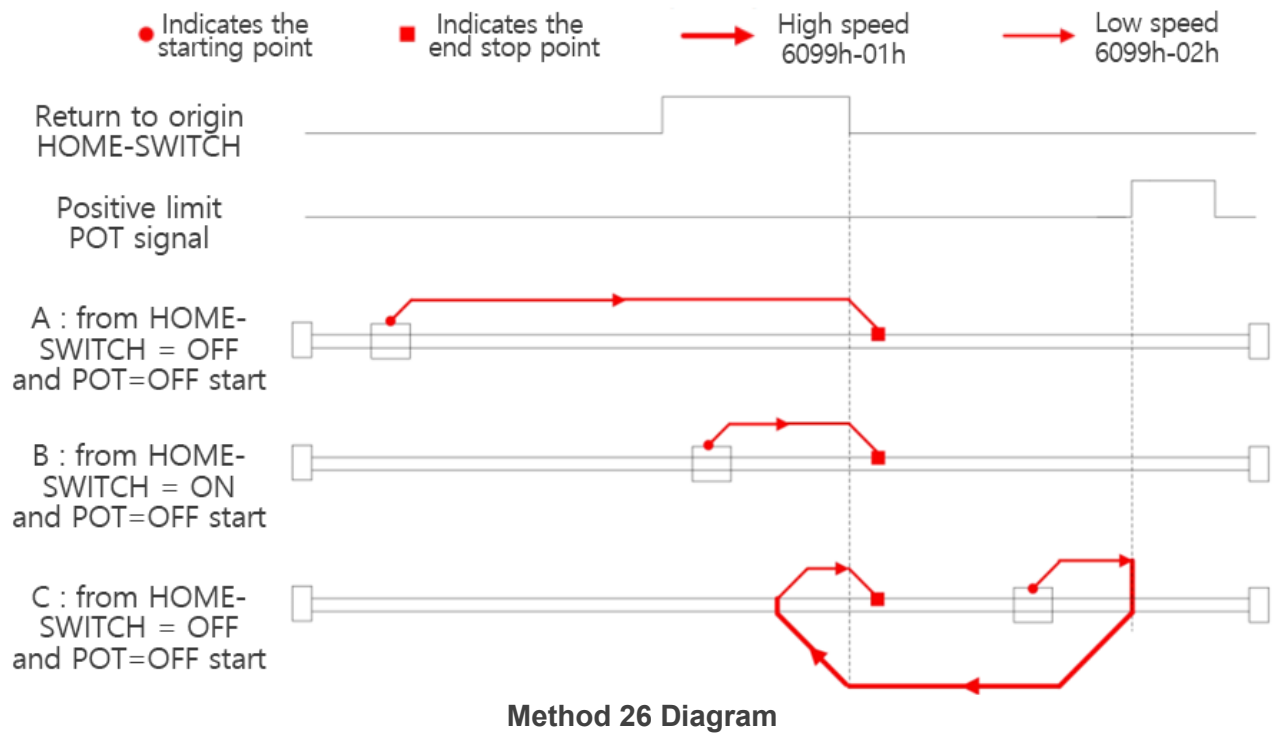
Method 24:



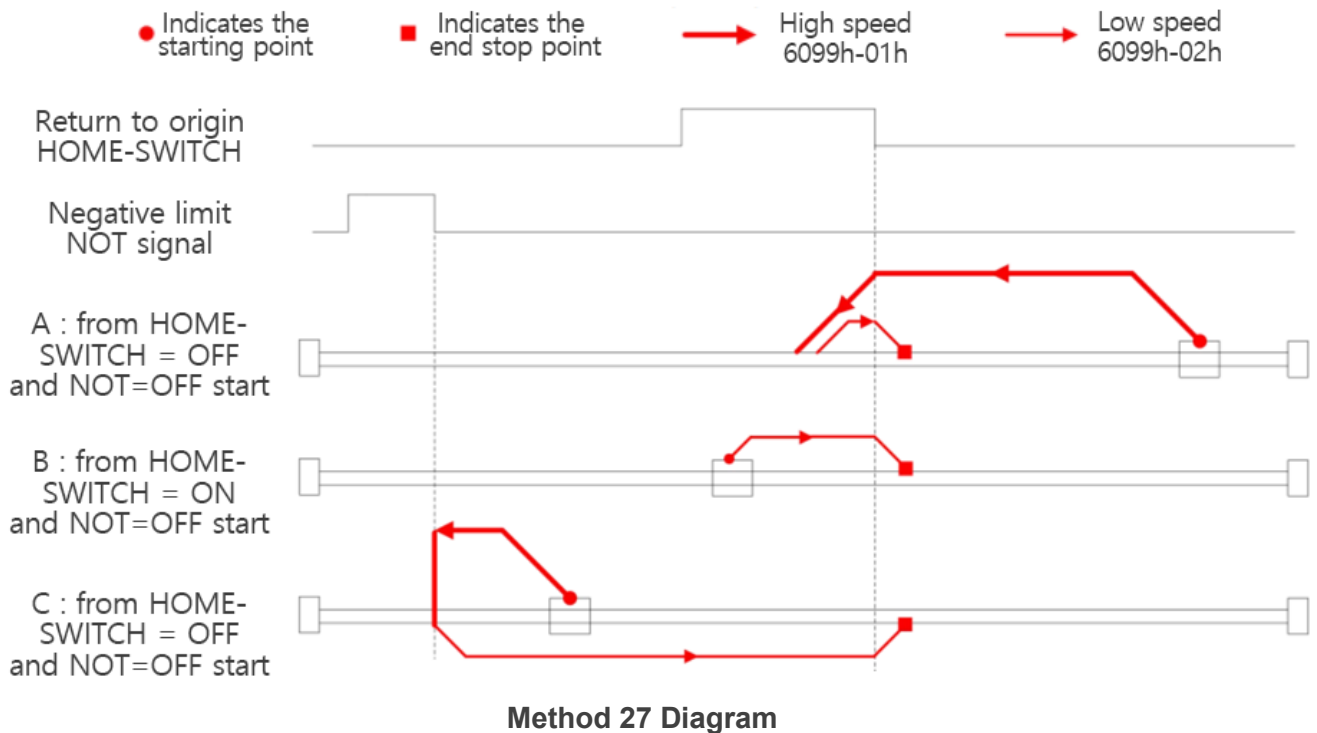
Method 25:



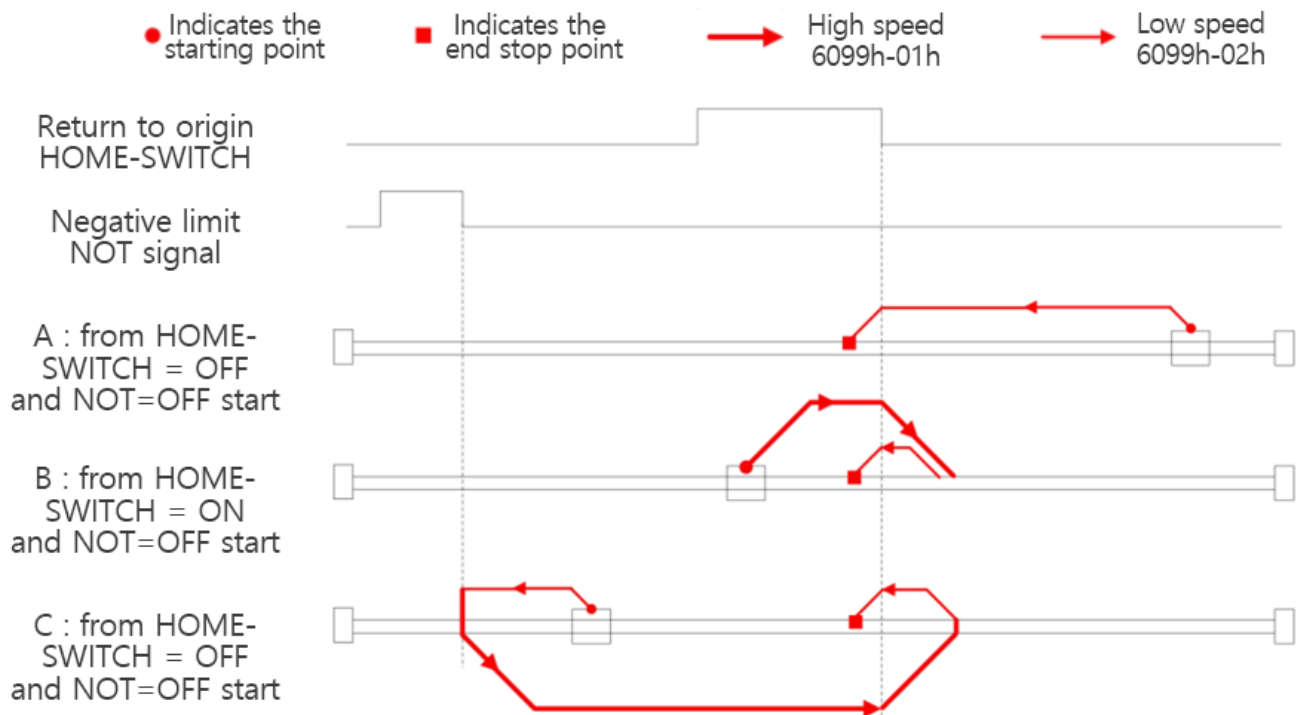
Method 26:



Method 27:

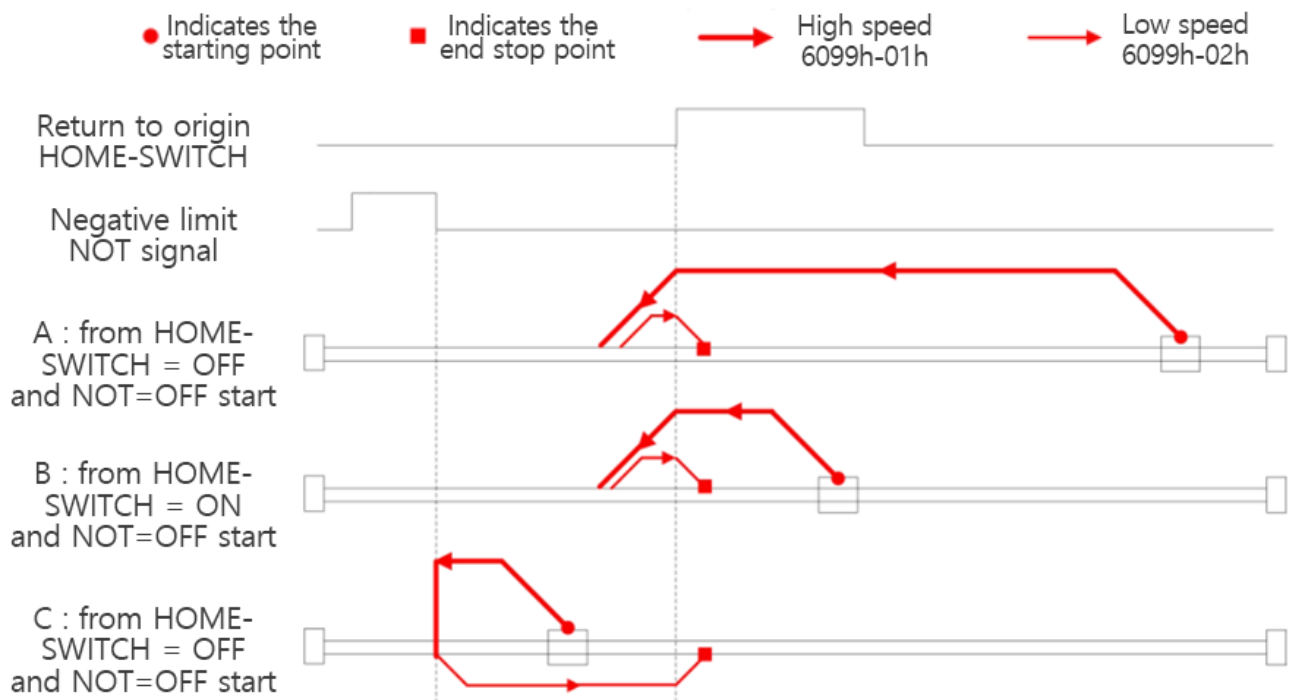


Method 28:



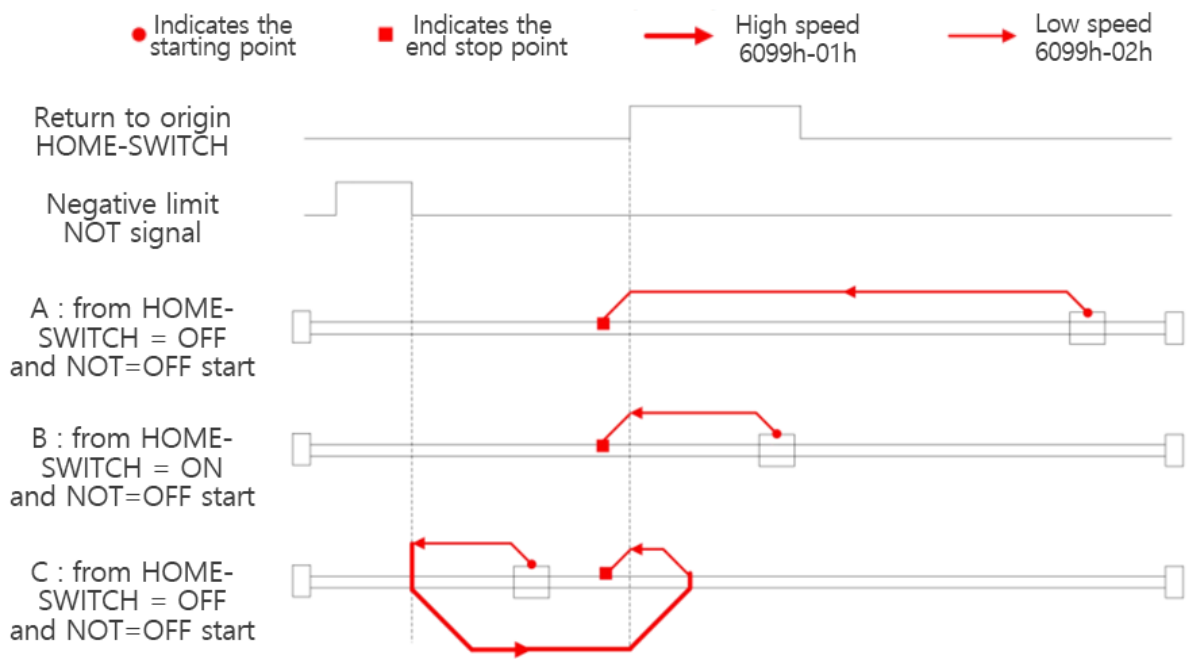
Method 28 Diagram

Method 29:



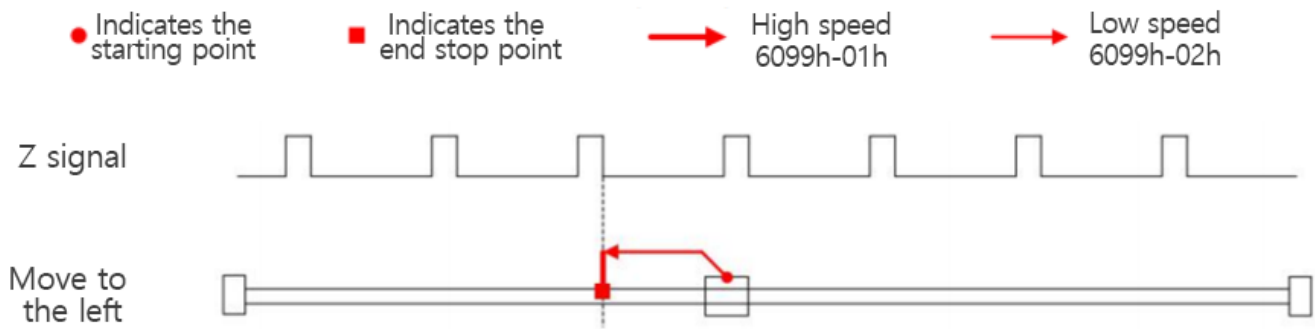
Method 29 Diagram

Method 30:



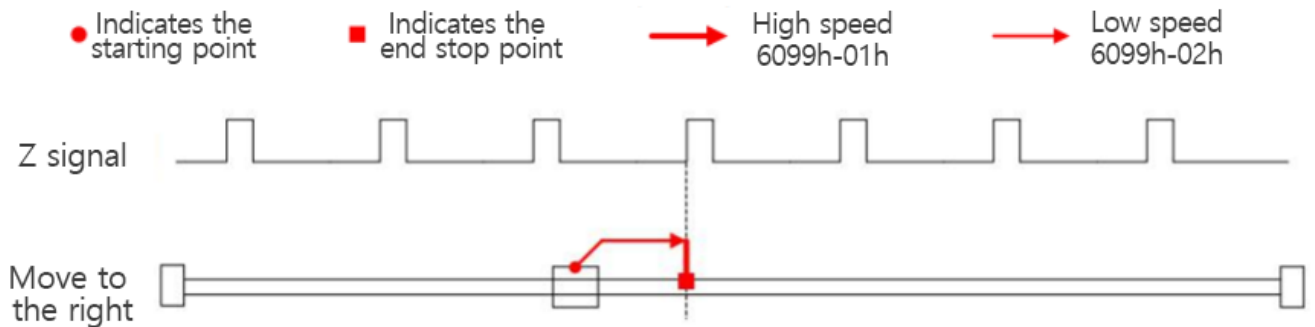
Method 30 Diagram

Method 33



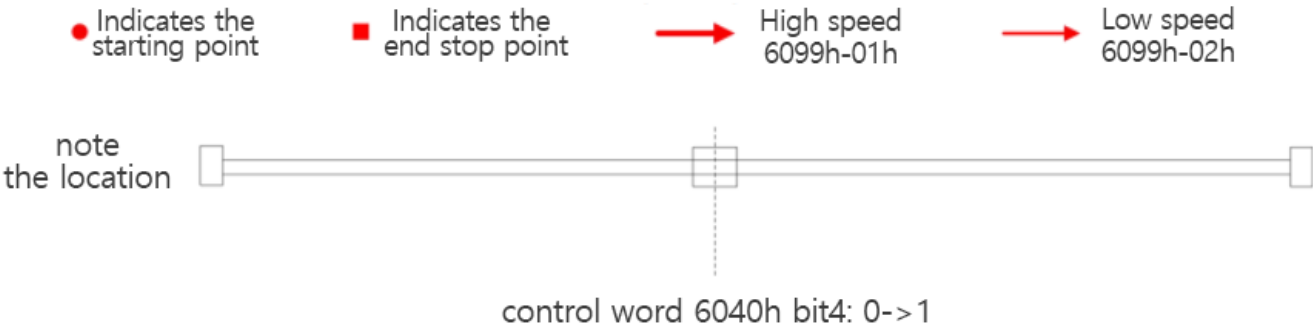
Method 33 Diagram

Method 34:



Method 34 Diagram

Method 35:



Method 35 Diagram



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